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ELECTRO-THERAPEUTICS
FOR
PRACTITIONERS

BEING ESSAYS ON SOME USEFUL FORMS OF
ELECTRICAL APPARATUS AND ON SOME
DISEASES WHICH ARE AMENABLE
TO ELECTRICAL TREATMENT

BY

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PREFACE

It is hoped that this small volume may fill a niche in the literature of a speciality to which not too much space has been given.

It is in no sense a text-book on electro-therapeutics—there are several such—but my aim has been to convey clear information as to some useful forms of electrotherapy, and to indicate those diseases in which this branch of therapeutics is most generally useful. As the facts are based on personal experience, and definite results have been obtained by the author, they are capable of being duplicated by any painstaking practitioner.

Finally, I beg to tender my very sincere thanks to many friends, on both sides of the Atlantic, who have rendered me so much kindly help in the attainment of the knowledge which it is here attempted to set forth, and but for whom it would have been impossible for this book to have been written.

F. H. H.

8 West Chapel Street,
Mayfair, London.

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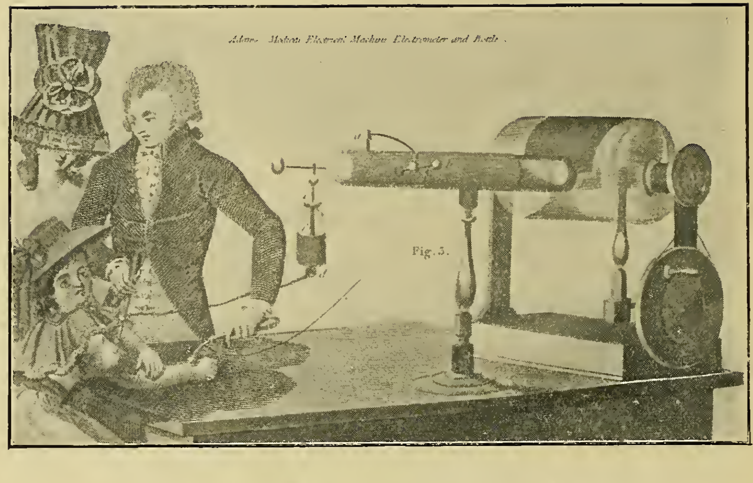
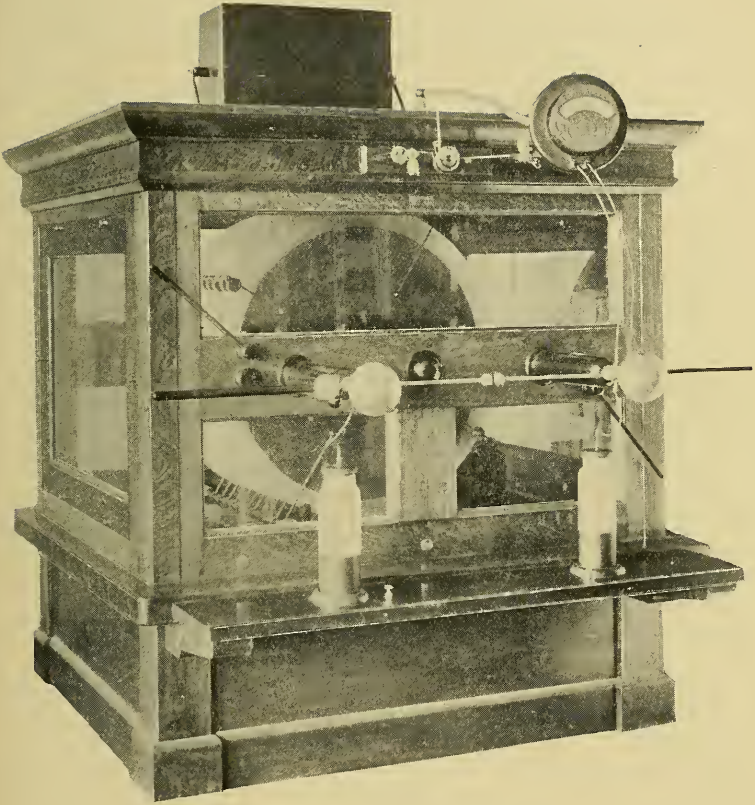

Adams Medical Electrical Machine Electrometer and Bottle.
Fig. 5.
a
d

A STATIC MACHINE OF TWO HUNDRED YEARS AGO.



A Static Machine of To-day.

ELECTRO-THERAPEUTICS

CHAPTER I

INTRODUCTION—HISTORY

To introduce the subject of Electricity properly one would have to go back to the time of Tiberius, when one Scriborius Largus, a physician, made use of the Raja torpedo-fish for rheumatism.

Electricity may be said to have been christened when Thales of Miletus (born 641 B.C.) found that amber (ἤλεκτρον) acquired by rubbing certain properties and developed a certain force—electricity. If anything may be said to be born some centuries after it was christened, then Priestley correctly termed Wilhelm Gilbert, the court physician of Queen Elizabeth, "the father of electricity," and very interesting it is to trace the history of medical electricity from these early times through the centuries down to the present day.

But the intended scope of this book is not that it should be either a history of electrical treatment or a text-book of the many ways in which it is possible to use electricity in disease, but rather to discriminate and explain the class of ailment which is pre-eminently suitable for treatment by this valuable therapeutic agent, to note those diseases in which it may be found useful, and to give an idea of apparatus which is used, and how that apparatus is made. Like many another useful remedy, electricity has been brought forward as a panacea for all ills, and when it has failed—the whole science has been discredited. It is worth while to consider for a moment the cause of the failure. Was the case suitable for electrical treatment? What electrical education or knowledge had the physician? (Let us hope he was a physician.) Was the apparatus, with the application of it, such as to ensure its success? When these questions can be answered satisfactorily in the affirmative, the failures should not amount to more than 10 per cent. of the total number of cases treated. Do we always get 90 per cent. of successful results when we are following the lines of the Pharmacopœia? That is about the percentage we should get in electro-therapeutics—about 90 per cent. of all cases undertaken should show a marked improvement, and in most cases this should be apparent after the first four or five treatments, often, indeed, from the very beginning. It has, in fact, been my habit and custom, as a rule, to advise the patient to discontinue treatment after the fourth or fifth day, should no improvement be manifest. I am not saying that with prolonged treatment some of these patients might not have improved later, but as a rule they have turned out more or less unsatisfactory cases, while those who show at any rate some amelioration of symptoms from the first usually continue to improve until a cure is effected. There is one thing in the rate of advance towards health to which I would like to draw attention: it is this — that patients undergoing electrical treatment rarely progress steadily. Improvement is, as I say, often manifest from the commencement, and then may continue for a day or so, each day showing some progress; then—and this occurs in the majority of cases—comes a period when the patient either gets a little worse, or seems to stand still—*the period of discouragement.* This period lasts for one, two, or three days, when improvement once more sets in, and the patient goes on to recovery.

There is another, but not so common, occurrence incidental to successful treatment, and this happens especially in joint affections — the patient will complain that a few hours after treatment, or perhaps the same night, the pain or the stiffness becomes worse; but in the morning or twenty-four hours after the first treatment, the joint shows improvement. This, I think, is due to some reaction set up by the electricity in the affected part, and may be interpreted as a favourable sign.

It may be pertinent to ask why, if electricity properly applied can promise relief to nine out of every ten people who are suffering from diseases for which it is indicated, has it fallen into more or less disrepute, especially in England. Three reasons I have already mentioned—a fourth is to be found in the use of electricity by unqualified persons. Not that they are in the wrong, or are to blame, as the law now stands; but it cannot be expected that people, whose knowledge of medicine and surgery may be assumed to be below that exacted by the licensing bodies, can prescribe certain forms and doses of electricity, note and appreciate the varying effects, modify and control the applications from time to time, and so bring the patient to the state of health for the attainment of which he sought treatment. Also, as with treatment by the more generally-accepted methods, so it is with electricity, that the diet may have to be modified—drugs may be needed in the treatment, signs and symptoms have to be observed and their significance explained to the patient, and surely it is he who has proper medical training who may be expected to do this rather than the unqualified person. To qualified men only should be entrusted electrical treatment, even as to a qualified surgeon the use of surgical instruments, or to a qualified physician the right to prescribe, or to a qualified pharmacist the right to dispense. What patient would allow an unqualified person to use a surgical instrument upon him, or expect to derive benefit from the choice of a man or woman selecting, well-nigh at random, a mixture from the bottles in a chemist's shop? If a patient wished to get the best result in medicine or surgery, would he not at least try to find out the best physician or surgeon; but when it comes to electrical treatment, with what is he content? And I would ask, if a successful result is not obtained, has the patient done all in his power to get that result? I would submit that electrical treatment should not be judged as it is judged in England to-day.

One point (which is elementary, but I fear often overlooked) is that each patient should be carefully examined before any treatment is undertaken: and for two reasons—firstly, a thorough examination may modify the form of treatment which at first suggests itself, since success depends not only on local, but on constitutional conditions, and, secondly, the patient may be in such a state of health that an untoward result may follow the exhibition of electricity, but yet have nothing to do with the treatment. As an example of what "might have been" in this connection I would cite the following case. Mrs. K., on November 20, 1911, was sent to me by her physician, complaining of indigestion and insomnia, which had lasted for years. She also suffered from chronic constipation. The indigestion always came on shortly after food, and the symptoms chiefly were pain, acidity, and flatulence, with occasional vomiting. There were no physical signs except that the heart sounds were somewhat weak and slightly irregular. The sphygmomanometer showed the maximum arterial tension to be 130. There was some increased frequency of micturition. Beyond these facts, there was nothing of importance to be elicited either by examination or questioning. She (as also her husband, who accompanied her) was very anxious to have treatment at once, but it was deferred until I had had an opportunity of a further consultation with her physician. The patient died that night in an anginal attack. If any form of electrical treatment had been given, who would have believed that it was purely a case of *post hoc,* and not *propter hoc?*

It may be thought that in the following chapters I have not confined myself sufficiently to electricity, but have unwarrantably wandered into the domain of the pathologist and of the anatomist; but to have an understanding of the uses of electricity, a clear comprehension is necessary, not only of the result which we wish to obtain, but also of the manner in which that result is to be brought about, a knowledge of the ground on which we are to work, and exactly how the morbid, unhealthy condition is to be altered into a healthy state. To attain success we must enquire what is the pathological condition, and how this may be remedied by some definite effect which some form of electricity is capable of producing. The effects obtainable from electro-therapeutic measures are—

mechanical, as in static electricity;
electrolytic, as in the constant current;
thermic, as in the D'Arsonval current;
actinic, as in glass vacuum tube currents;

and it is only by keeping clearly in view these effects that the appropriate current will be selected, and the pathological condition relieved. The diseases of which I have written are those in which I have found electricity most generally useful. Broadly speaking, any pain which cannot be relieved by the appropriate form and dose of electricity should be promptly referred to the surgeon. I think pain may be said to be one of the chief indications for the selection of electricity as a remedial agent. The next great class in which it is most useful is that form of neurasthenia with its attendant insomnia, &c., which is caused by over-working, or too much gaiety; here its action is almost specific. In certain skin affections and some forms of malnutrition electricity may be relied upon to produce results. These and other diseases and the way in which electro-therapeutic measures are of most use form the subject-matter of the following chapters.

CHAPTER II

APPARATUS

THE necessity for a full armamentarium cannot be too strongly impressed upon the physician who would get uniformly good results with electro-therapeutic measures. Of course even as a certain amount of good work may be done with only a couple of drugs, so a certain amount may likewise be done with one galvanic battery and, say, a four-cell bath. But the field is then limited, and though there are many still working in the limited field, to whom electricity is only electricity—yet to the specialist who is constantly using that agent to a therapeutic end, no fact is better known than that he must have ready for instant use very many and different kinds of apparatus in order to treat with success the varying conditions which present themselves. The different forms of electricity are not interchangeable. If a case is pre-eminently suitable for static treatment, no amount of current from the galvanic battery will serve equally well, and *vice versâ*. It would be impossible to get the brush discharge suitable for a neurasthenic from a galvanic battery, although I am not saying that the patient could not be treated with galvanism; but in a case where the spinal brush discharge would be the best treatment for him, the static machine alone is capable of giving it. Similarly, if a salicylic ionization were indicated, no amount of static electricity would replace the constant current, even though the affection might be one which could be treated with static electricity. In each of these cases one form of treatment must be the one really indicated, the therapeutic agent which is the best for that particular individual, and unless the physician has that particular one, is he not apt to give of what he has, and hope for the best, blaming electricity in general if his results are not all he expected, or hoped?

The secret of success lies in the choice of the appropriate modality. No one would walk into a chemist's shop, pick a bottle up at random, and take it with expectation of a cure. Yet how many sufferers buy a battery, and expect relief from electricity?

Probably the current which is most widely known in electro-therapeutics is the direct, constant, or galvanic current. It would be superfluous to describe the apparatus used for its production. So long as the apparatus is in good order, it matters little whether the current be derived from dry cells or wet cells, or from any of the various transformers on the market. It is of great importance to have an accurate milliampere meter in circuit, and also some device for gradually increasing and decreasing the current. So much depends upon the current being slowly and evenly turned on and off. Not only will the patient be more comfortable if the current be deliberately increased without a suspicion of a jerk, but he will be able to bear greater milliamperage to the same area of electrode. Most of the apparatus on the market would be improved if some device were added so that this manœuvre were made more easy to accomplish. Personally I have had a wheel and ratchet with a fine screw attached to the rheostat, and this I find to work more easily and evenly than anything I have used, except Massey's circular graphite rheostat. Of course it may be that we wish to use the current in a different manner, and to cause contraction or stimulation by a sudden alteration of the make and break. This may be done by hand, or by a metronome reversing the current at each stroke, or by various other mechanical devices. An accurate milliampere meter allows the dose to be made proportional to the size of the electrode, and to be measured, with the help of a watch, in milliampere-minutes.

I am not going to describe the electro-diagnosis or the reaction of degeneration, although I do not wish to minimize their importance, but they are already in every text-book teaching electricity, and in most books dealing with the nervous system.[1]

Faradization certainly has its uses, though it has brought much discredit upon the use of electricity. "The wicked little wooden box" is carried from patient to patient by those whose knowledge of electricity can hardly be called scientific, and when the patient has endured some indefinite faradic application, and derived no benefit, the verdict is: "Oh, I have tried electricity, and it is no good." Not that faradism has not its uses. For the exercising of muscles without fatigue, it is still probably the means *par excellence*, more especially if it is provided with the mechanical surging, as in the Gaiffe apparatus, and in several similar batteries. Much that has been said of the faradic applies to the sinusoidal current, though with the latter more reliable effects are apt to be produced.

---

[1] See *The Diagnosis of Nervous Diseases*, chap. xxii., Purves Stewart. Edward Arnold. 1911.

For high frequency currents a great deal has been claimed, and certainly results have been published by some which other workers have been unable to duplicate. (Under the term high frequency I am here limiting myself to the currents of D'Arsonval, Oudin, and Tesla.) Of these results the most important is the reduction of an abnormally high arterial tension and the production of local hyperæmia. High frequency currents can be derived from either a static machine or a coil with suitable condensers and solenoids. The most modern and effectual form of high frequency will be found described in the chapter on Diathermy.

A good coil is a comfort. It may be needed as an alternative to the static machine for the production of X-rays, or for the source of current for high frequency; and no physician who has used one would willingly be without it.

A static machine is indispensable, as is a high candle-power light; in fact, these two agents I should be inclined to put in the chief place in the armamentarium. They are more frequently required than anything else in electro-therapeutics, and results are obtained by their use in so unvarying a manner that one gets to rely upon them, and they become indispensable.

A last word, or two words, on apparatus. In the first place, it should be the best procurable, and, in the second, it should receive daily care and cleaning. Whether any particular piece of apparatus is going to be used in the day or not, it should be cleaned and ascertained to be in good running order. So surely as these two points are deviated from, there will come a day when the apparatus will fail to work, possibly when it is most needed, and then more disrepute will fall upon medical electricity.

CHAPTER III

STATIC ELECTRICITY

Therapeutic history is full of the stories of various agents which come heralded with much noise and advertisement, and have a sensational rocket-like rise; then suddenly their light goes out, and they are forgotten.

This cannot be said of Static Electricity. Discovered about 1672 by a Burgomaster of Magdeburg, Otto Guenicke, it cannot for many years be traced; but in 1750 Tallabert, professor in Experimental Philosophy in Geneva, published a book in twelve chapters, *Experimenta electrica usibus medicis applicata*, in which the successful treatment of diseases of the muscular and nervous systems by means of static electricity is described. Thus it was used as a therapeutic agent prior to 1750, and it has withstood the test of time since then, its efficiency and practical utility gradually increasing until now, when it may be said to have reached so high a degree of scientific perfection that, as a therapeutic agent, its claims cannot be overlooked.

Fifty years after static electricity had been used as a remedial agent, galvanism and faradism were discovered, and for a time it dropped into disuse, owing, on the one hand, to the comparative ease with which galvanic and faradic batteries could be made, kept in order, and relied upon to give electricity when required, and, on the other, to the lack of knowledge as to how to construct a reliable static machine. To-day it is different, and trustworthy machines are being sold by the hundred—their therapeutic advantages and the wide range of utility of static currents being generally admitted by all those who have thoroughly examined their merits. This change is of comparatively modern date, having been brought about within the last fifteen years, and is due chiefly to the work of Dr. Morton and Dr. Snow, both of New York.

It is now being claimed that various high frequency currents will displace static electricity, and patients are told that the effect is the same. In reply to this I would quote from a report on this question given to the Twenty-first Annual Meeting of the American Electro-therapeutic Association: "The men who claim this are either warped in their judgment, or they are ignorant of the currents and therapeutic effects of the static machine. It is a fact that no other high potential apparatus has yet been produced which will induce the physical effects of the tissue pulsation, with resulting tissue drainage."

I will admit that there are certain disadvantages in the employment of static electricity. The machine is large, it is expensive, and it requires a certain amount of special study; but are these sufficient reasons for denying to patients the benefits to be derived from it?

When we come to consider the physiological effects of static electricity, it is clear why its field of usefulness covers so large an area. Among the effects of static currents they—

In the Circulatory System,
    (*a*) modify arterial tension,
    (*b*) lessen heart frequency,
    (*c*) lengthen diastole,
    (*d*) increase pulse volume;
In the Respiratory System,
    (*a*) relieve rapid and laboured breathing,
    (*b*) cause deeper breathing, with an increased elimination of the carbon dioxide;
In the Nervous System,
    (*a*) relieve irritability,
    (*b*) induce soporific effect;
In the Vaso-motor System,
    (*a*) induce diaphoresis,
    (*b*) induce diuresis, with increased elimination of urea, and cause an increase in general metabolism.

Electricity, in all its forms, has its opponents (what, indeed, of any worth has not?), and static electricity proves no exception, the bright side to the picture being that its opponents form a class which is rapidly diminishing. Let us see what are some of the reasons for the opposition.

One was the inferiority of the machine used. A physician using such an one has poor results, becomes disgusted, and gives up its use; but for similar reasons it was given up a hundred years ago; and that has not prevented its gradually-increasing general use throughout the world to-day, now that well-constructed and reliable machines are easily obtainable.

Another reason for opposition to it may be that it has been used by charlatans and quacks; but surely so much more is it the duty of the profession to rescue it from such, and give their patients the benefit of an intelligent application of its many advantages, guided by a well-grounded knowledge of anatomy, physiology, and therapeutics.

Perhaps yet another reason for the failure to get results, and hence for opposition, may have been insufficient knowledge on the part of the practitioner. But it was this that produced burns from X-rays, when our knowledge of that agent was not so great as it is at present; yet now that we know that we need not produce a dermatitis unless we wish, this no longer deters us from using X-rays, or justifies us in depriving our patients of their advantages.

Static electricity is of use either by itself or as an adjunct to other forms of treatment in so many diseases that one is almost afraid to enumerate them.

In the *Lancet* (Feb. 2, 1904) I published a chart of Static Modalities in which, in the column headed "Indications," were set forth most of the diseases in which static electricity has been found useful. It is here reproduced, and I trust will not be misinterpreted. (See pp. 12 and 13.) It is not claimed that static electricity will cure all diseases set forth in that list, but it is asserted that static electricity has given good results in those diseases, and is constantly doing so, and, scientifically applied, may be relied upon to do so again.

Static currents are replaceable with no other form of electricity, and, with a competent knowledge of their uses, therapeutic effects can be obtained from them which appear marvellous to any one using them for the first time. To

A CHART OF

Class.	Name.	Connections for Poles and Electrodes.	Leyden Jars.	Insulation of Patient.	Requisite Electrodes.	Spark Gap.
Conductive.	Static Induced.	Both to Leyden Jars, and both thence to patient.	Yes.	No.	Metal, water, or wet clay to bare skin or to mucous membrane.	Closed to begin, and gradually open to tolerance of patient.
	The Wave Current.	Pos. to patient. Neg. to ground.	No.	Yes.	Metal or metallic cloth, water, or wet clay to bare skin or mucous membrane.	As Static Induced.
Disruptive.	Sparks. Indirect and Friction.	Neg. to platform. Pos. to ground.	No.	Yes.	Brass balls.	Wide open.
Disrupto-Convective.	Brush Discharge.	Pos. to ground. Neg. to patient or platform. Electrode to ground.	No.	Yes.	Made of wood of various sizes and shapes, also ordinary whisk broom, also of glass made hollow and filled with glycerine and water. May have tips of varying shapes and materials.	Wide open.
Convective.	Breeze and Spray.	Pos. to patient or platform. Neg. to ground. Electrode to ground.	No.	Yes.	Usually brass point, single or multiple crown or broom metal fly brush.	Wide open.
	High Potential Vacuum.	Pos. to ground. Neg. to electrode.	No.	Yes, as a rule.	Special glass vacuum.	Begin ¼ inch and gradually regulate to a maximum of 1 inch or even 2 ins.
	The Static Bath or General Electrification.	Usually Neg. to patient or platform. Pos. to ground. *Note.*—These are the usual connections. It sometimes happens that the reverse may suit certain cases.	No.	Yes.	None.	Wide open.

Physiology and Therapeutics. (After Snow.)	Special Indications.	Remarks.
Subjective— *a.* Induces muscular contraction. *b.* Induces physiological tetanus. *c.* Induces local vibratory effect. Clinical— *a.* Relieves local pain. *b.* Relieves local congestion. *c.* Increases secretion.	Obstinate constipation. Painful neurosis. Obesity.	The constitutional effects of this current are practically *nil*, the local effects very similar to those of the Wave Current.
Subjective— *a.* Produces local vibratory effect. *b.* Induces muscular contraction. *c.* Induces physiological tetanus. Clinical— *a.* Diminishes local swelling and congestion. *b.* Relieves local pain. *c.* Relieves acute muscular spasm. *d.* Increases local and general metabolism.	Insomnia, neuralgia, sciatica, and other neuritis, locomotor ataxia, rheumatism, gout, lumbago, synovitis, bursitis, relaxed ligaments, sprains, pelvic congestion, dysmenorrhœa, enlarged prostate, dyspepsia, constipation, goitre, a general tonic to influence metabolism, nephritis.	During the application of this current to extra sensitive areas, *e.g.* forehead, eye, ear, nose, and throat, it is advisable to do away with the negative grounding. The two forms of the intensification of this current have been omitted; they are more local and less constitutional in their effect; when this (the unmodified) current cannot be used, then the Static Induced current is indicated.
Subjective— *a.* Produces stinging sensation. *b.* Produces muscular contraction. *c.* Produces blanching, followed by redness, wheals, and even blisters, by successive applications. *d.* Increases local secretion. Clinical— *a.* Produces relaxation of muscular spasm. *b.* Produces relief of pain. *c.* Lessens hyperæmia and swelling.	Much as wave, but it is a more severe form of treatment. It is useful also in paralysis. It is the best diaphoretic of all Static currents.	There is also the Direct Spark; it is very severe, and only of use in humid weather. In other respects it resembles the ordinary spark, but the Pos. connection is to the patient and the Neg. to the Electrode. The currents in order of preference for the relief of pain: 1. Wave. 2. Brush. 3. High Potential Vacuum. 4. Sparks. 5. Breeze. 6. Spray. 7. Static Bath. 8. Static Induced.
Subjective— *a.* Increases local secretion. *b.* Acts as rubefacient, if pushed. *c.* Acts as local antiseptic. Clinical— *a.* Relieves local congestion. *b.* Lessens local swelling. *c.* Diminishes local pain. *d.* Promotes local metabolism. *e.* Destroys superficial septic processes.	Neurasthenia, early acute rheumatism, and where the part is very sensitive. Sprains, swelling, and other traumata, early stages of most acute inflammations. Tubercular and other ulceration, and most forms of congestion or stasis with or without germ life. Indurated margins of wounds.	
The effects are the same as the Brush discharge, but are more irritating and less effective.		The Pos. breeze is stimulating, the Neg. is sedative. The Neg. breeze is where the Neg. pole is connected with the patient.
	Fissure, rectal ulcer, hæmorrhoids, acne, and other skin affections, pruritis, catarrh, and hay fever.	Ozone evolved. . . Vacuum electrodes *without* wire are preferable, because they are less liable to puncture, cheaper, and equally efficient.
	Where a general sedative is needed as a prelude to, or in conjunction with, other forms of treatment, especially after a Radiant Heat Bath. Neurasthenia and nervous irritability, especially when accompanied by high Arterial Tension; very useful in the nervousness of alcoholics and as an adjunct to the treatment of inebriety.	From the Static Machine many other currents can be derived, such as those of D'Arsonval, Tesla, and Oudin. The Static Current will excite an X-ray tube with a radiance which is remarkably steady; the steadiness being due to the lack of inverse current.

get these effects consistently, however, two factors are essential—

(1) A proficient knowledge of static electricity, its characteristic effects, and of the nature of the disease to be treated.

(2) A static machine of efficient power.

Some of the advantages of static electricity are that the applications are for the most part not unpleasant, that they are perfectly safe, and that the beneficial results obtained are apparent from the beginning of the treatment.

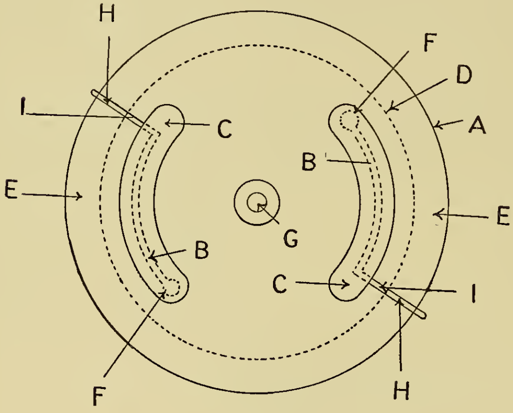


FIG. 3.

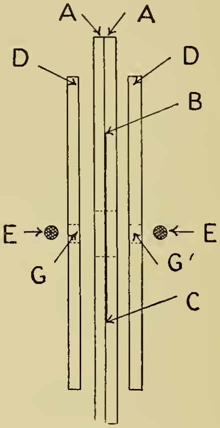


FIG. 4.

A. Stationary plates.
B. Metallic field inductor.
C. Paper armatures.
D. Revolving plates.
E. Positions for collecting combs.
F. Positions for neutralizing combs.
G. Rosette.
H. Positions for field combs.

The accompanying diagrams will give some idea of the construction of the static machine.

From the earliest days the gravest charge brought against static electricity is that it is unreliable, especially in damp climates; and the fact that moisture is an ever-present enemy, which only unceasing care can combat, has undoubtedly militated enormously against the more general use of this valuable agent. When there is difficulty in charging the static machine, when it is generating a current below its capacity, when it frequently changes its polarity, then it is that moisture has affected it. In a dry sunny climate it is doubtful if any complaint would be heard of trouble in connection with static electricity, and if proper precautions are taken, little, if any, trouble should be experienced in climates however damp.

A house as dry as possible in position and construction should be chosen, and a sunny room in it, in which to place the static machine. Some form of drier must be placed within the case. At one time I had made a cylinder which could be filled with ice and salt. When this was revolved the moisture within the case collected upon it in the form of ice, and could be scraped off. This is very successful, but too cumbersome and troublesome. Calcium Chloride is often used as a drier, but there are several objections to it; chief among which is that as it absorbs the moisture it also decomposes, depositing upon the plates a sticky coating

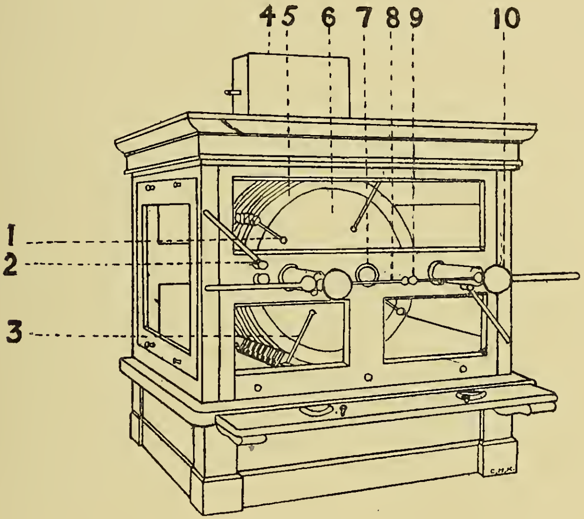


Fig. 5.

1. Field combs.
2. Field regulator.
3. Neutralizing combs.
4. Exciter.
5. Stationary plates.
6. Revolving plates.
7. Rosette.
8. Sliding rod.
9. Sliding rod balls.
10. Large balls.

which impairs the capacity of the machine. Snow introduced the use of ordinary quicklime (Calcium Oxide), placed in boxes made of laths and covered with two thicknesses of fine linen, using about 20 pounds of lime and changing it once a month, and I have followed this plan with great success. Pure sulphuric acid in glass dishes, too, I have found most effectual. I use ordinary flat fruit dishes, and cover the floor of the case with these and half fill them with the acid, changing them when the dishes are nearly full, for by absorbing the moisture from the air, the acid becomes diluted and would overflow the dishes unless these were removed. The last few months I have been using calcium oxide in its covered boxes and sulphuric acid in dishes, both in the same case, with improved results. In an emergency, when the weather is very warm and damp, CO_2 may be forced into the case for a few moments. This was first tried by me in the summer of 1911,[1] but except for the days on which I conducted the experiments I have had no occasion on which to use this agent. Certainly the initial experiments gave reasonable hope of a valuable method of inducing the machine to charge and obtaining an increased output under the most unfavourable conditions possible; but under ordinary circumstances quicklime or sulphuric acid will meet the needs of the practitioner. (See note at end of chapter.)

In addition to keeping driers within the case, it should be well rubbed down daily on the outside, and the machine must be thoroughly cleaned from time to time. It is impossible to say how often this should be done, as it depends upon the kind of weather, the amount of work done, &c.

It is important to be able to recognize the polarity of the static machine, for it is not always the same. It may charge up differently on any occasion on which it is charged, and even when not working well may change polarity while running. The polarity is determined by the appearance of the current either at the terminal balls or at the collecting combs.

When a stream of sparks is passing between the former it is brighter and whiter at the negative side, and of a more violet tinge on the positive.

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[1] A contribution to the Report of the Committee on Static Electricity on the use of Compressed Gases for increasing the efficiency of the Static Machine. F. Howard Humphris, *The Journal of Advanced Therapeutics*, February 1912.

If the balls are drawn so far apart that a spark will not pass, the discharge will appear as a fan-tail radiating in straight lines from the negative side, while from the positive it has the appearance of forked lightning.

Again, if the wooden ball electrode be brought near the terminal balls, it will be seen that the current will follow the stick on the positive side, but will not do so when brought near the negative terminal. But perhaps the easiest way of all is to look inside the machine, when the points of the collecting combs on the positive side will be noticed to be tipped with bright points, while those on the negative side have a violet flame or brush coming from them (a simple *memoria technica*, "Positive Points," will impress this on the mind).

It may be observed that in this country (England) and on the continent of Europe the medical profession in general, and the specialist in electro-therapeutics in particular, have not given this subject that same careful consideration which has yielded them success in other branches of therapeutics; but should ever this happy state of affairs obtain, as much will be heard of static electricity as of ionization or vaccine therapy; possibly more.

A NOTE ON A DESICCATING APPARATUS

With a view to an improvement on the already-mentioned drying methods, and consequent efficiency of the machine, I am having made an apparatus which is designed to fill the interior of the case with desiccated air.

The amount of moisture in a certain volume of air depends upon the temperature of the air and the pressure to which it is compressed. This apparatus consists of a power-operated air-pump suitably designed for pumping air through specially-prepared desiccating apparatus, consisting of one or more cylinders filled with calcium chloride.

The air passes through the desiccating cylinders in question in series, and in such a way that the calcium chloride may extract as much of the moisture as possible from the air on its passage through. This air, under slight pressure, and after being freed from moisture, passes into the lower end of one side of the machine; the upper and opposite end is provided with an escape valve.

The operation of passing the air through is continued until the necessary degree of dryness has been reached: the volume of air pumped in and the pressure at which this air is delivered depend upon the results obtained. Whether it will be necessary to lower the temperature of the cylinder by means of CO_2 or some similar means, and how often the apparatus will have to be used to change the air in the static machine, can only be determined after it has been running for some time.

CHAPTER IV

THE STATIC BATH

Sometimes called Static Electrification, or General Electrification. This is in its manner of administration the simplest and most pleasant of all forms of static electricity; unfortunately, however, it is not so efficient as some others, nor are its therapeutic effects so marked; and the indications for it do not cover a very wide range. But where a constitutional sedative is required to the otherwise healthy but generally tired-out individual, or to a very nervous, highly-strung patient, its effects are excellent, the patient often falling into a gentle sleep during its administration, and awaking much refreshed and soothed.

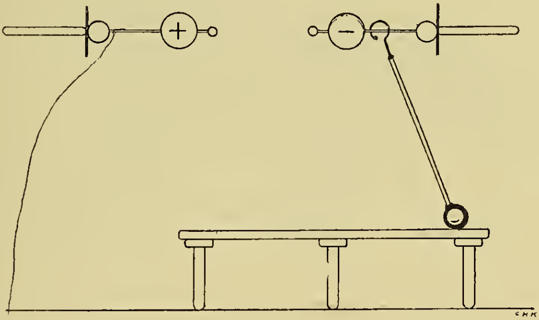

Fig. 6.

Diagram of the Static Bath.

Its technique is simple, but the details must be carefully followed in order to get the full calming effect of the current.

The terminal balls are drawn as far apart as possible, and the shepherd's crook reaches from the negative side of the machine to the insulated platform, or a wire may lead from the negative sliding rod to the lower bar of the chair. The patient reclining on the chair, comfortably supported by cushions, is placed for the most part opposite the pole with which he is connected. The most convenient chair is that devised by Snow. It is made of wicker, and has no metal in its composition, and admits of all the positions needed in the administration of the various static currents.

The positive side of the machine is grounded. Care must be taken to see that there is no metal braid in the cushions, that the platform is well away from the wall or any other object, and that the patient is not conscious of any metallic clothing, metal hairpins, &c. When the current is turned on, the patient should feel little except a sensation as of wind passing all round him, or the hair being raised from the head, but there is nothing alarming even to the most nervous patient; the sensations are quite pleasant.

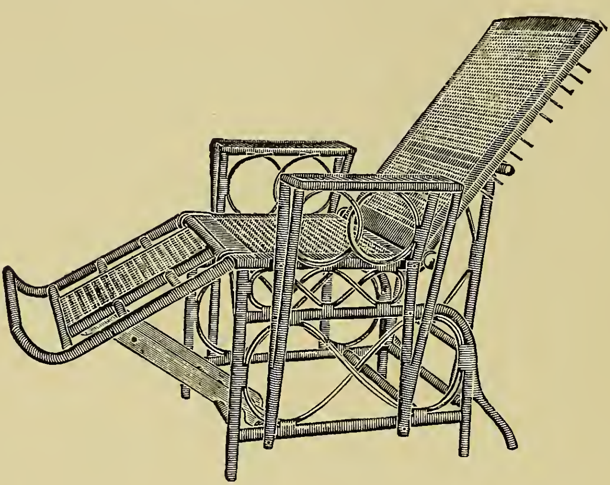

FIG. 7.

Static Chair.

The raising of the hair is quite a striking phenomenon in the administration of this current. Its explanation is simple. The hair acts as a separate capacity to that of the patient's body, and acts in accordance with the general law of electrically-charged bodies. "Like repels, unlike attracts." The hair being charged equally with the patient's body negatively, is repelled from it, and hence stands on end, and incidentally acts as a conductor, conducting the current away from the patient and towards the oppositely charged capacity, viz. the ceiling, the wall of the room or any object standing near; thus exemplifying that other law in electricity dealing with the escape of static charges from points.

There is a form of this current in which the terminal balls are approximated so that we have a spark, or a spark-gap has been put in circuit with the connection between patient and machine. This current was termed Potential Alternation or Interrupted Electrification; it serves but little, if any, practical use.

As to the manner in which the current causes its effects it is difficult to speak. Experiments have been made which give negative results as to any demonstrable physiological action. But to any one who has used this current properly it is evident that in some definite way the effects are produced, and with some diffidence I suggest the following hypothesis. It is known that any uninterrupted static current has a tendency to flow over and remain on the surface of the charged body. When one considers that this current of 500,000 volts, or more, is flowing continuously over the delicate nerve endings in the skin of the whole body, the thought presents itself that it may gently stimulate them and produce a sedative effect in the internal economy.

It is not to be assumed that there is no penetration of the static current in this particular method of applying it, but the hypothesis is put forward to attempt to explain how the clinical results might follow did we only get the surface charge. Of course, there is not a true static charge here at all; negative charges are being constantly conveyed away, hence it is classified as a convective discharge. Negative charges are constantly coming from the machine to the patient, who may be said to represent the inner coating of a Leyden jar, while the walls, ceiling, and floor, &c., constitute the outer coating, the air and the glass legs of the platform being the dielectric. The patient's potential keeps on increasing until the maximum is reached, and a static charge would be effected were the air a perfect dielectric.

But it is not; it is more or less moist. In it there are a variety of dust particles, and it is constantly in motion, all of which causes leakage—*i.e.* the negative electricity is constantly being carried away by convective discharges, and as it is carried away, so fresh current comes from the static machine to replace it, so that a continuous flow is taking place all over, if not through, the patient.

The static bath current is indicated in cases of nervous irritability, or indeed in any form of nervousness, whether brought on by worry, over-work, or trouble and anxiety. I have seen it do good to patients who have recently undergone some great excitement, and to patients who have recently lost relatives, as well as to those who were about to undergo nervous strains. It is also good in the nervousness or vague ill-defined fears of alcoholics. Twenty minutes to half an hour, or even more, of this treatment will produce a marked diminution of the nervous irritability and a feeling of drowsiness, together with a sense of lessened fatigue and a capability for either work or enjoyment.

Urinalysis shows that the urea output is increased and that phosphates are decreased, so it will be seen that perhaps though not so useful in some of the more definite and painful diseases, the static bath is a form of treatment which has a definite sphere of usefulness, and one which, used where indicated, is a valuable and not to be neglected therapeutic agent.

CHAPTER V

THE STATIC BRUSH DISCHARGE

In 1786 was published a third edition of a book, in two volumes, by Cavallo, *A Complete Treatise of Electricity in Theory and Practice, with Original Experiments,* in which this current was first described as "the electrode fluid coming from a wooden point," and this description holds good to-day.

It is essentially a unidirectional, high-potential, convecto-disruptive discharge. It is of a violet colour, rich in ultra-violet, violet, and blue-violet rays, the colour being due to the fact that the discharge, in its passage through the air, renders the atmospheric particles luminous. Its passage through the air is attended with the formation of ozone and nitrous oxide. The presence of the former may be easily demonstrated by the following experiment. Place a metal plate connected to the negative side of a Static Machine in a bowl, cover this with a solution of starch and Iodide of Potassium, then bring towards the bowl a grounded positive electrode, when the solution will instantly turn a blue colour. This discharge in France is known as the *effleuve,* but as this term is also applied to a current of similar appearance derived from a high frequency coil and resonator, it is almost as unfortunate as the term "Brush" itself, conflicting as this does with the use of the same word in electro-physics.

The technique of this current is as follows: The electrode consists of a moist wooden stick (a soft porous wood, which will absorb a certain quantity of moisture, should be chosen, white maple being the wood *par excellence*). This electrode may have either a wooden point or ball at its extremity, or it may have a metal tip. Those devised by Dr. Snow, of New York, are exceptionally convenient (Fig. 8). Or the electrode may be a glass tube having a wooden point and filled with a mixture of glycerine and water (Fig. 9). These electrodes are from 24 to 30 inches long, and provided with a ring for the purpose of attaching a ground chain. In the case of a wooden electrode, it should be provided with a sliding collar with a ring for the attachment of the ground chain, so that this may be moved up and down the electrode, increasing and decreasing resistance as the case demands. This collar with the ground chain should be held in the hand. Under no condition should the operator hold the electrode with his hand between patient and the earth connection, lest spark occur between this and his hand. It is advisable to have several—say half a dozen—electrodes; for it is difficult, more especially for the beginner, to keep them in order—that is, to keep them at that stage of moisture at which they will be most efficient. I have found that rubbing them over daily with equal parts of glycerine and water gives the most satisfactory results. If the electrode be too wet, then there are too many sparks, and the current becomes almost wholly disruptive; whereas if it be too dry, it is difficult to get the current to flow. An ordinary whisk broom may be used as an electrode, and this is useful for a first treatment, for the mildness of the current will give the patient confidence, which may be somewhat shaken when he sees the violet stream between him and the electrode. I have even used a small camel's-hair brush in certain forms of conjunctivitis. Another useful electrode is of French make,

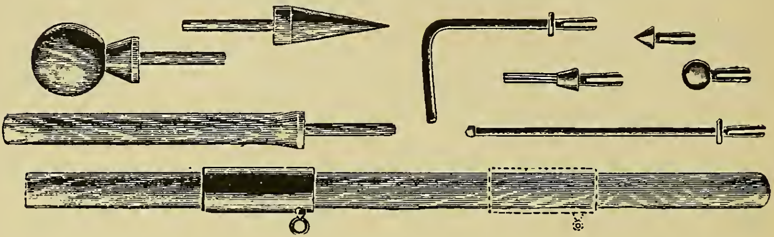

FIG. 8.

Electrodes for the Static Brush Discharge.

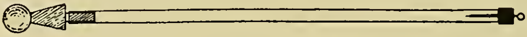

FIG. 9.

Neely's Fluid Electrode.

and consists of innumerable fine wires arranged in the form of a hemisphere (Fig. 10).

The electrode is connected by means of a chain to a good earth connection, unless a particularly mild current be required, when this may be omitted.

The patient is placed on an insulated platform, sitting or standing as the part to be treated may require. When the static machine is not very powerful, the patient should have a metallic connection to the negative side of the machine, the best way being for him to place his bare feet on a metallic plate, which itself is connected by means of a wire or the shepherd's crook to the machine. But when the machine is of sufficient power, it is enough to connect the platform by means of the crook to the negative.

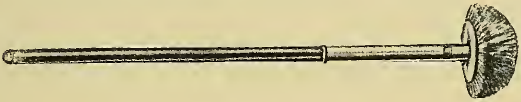

Fig. 10.

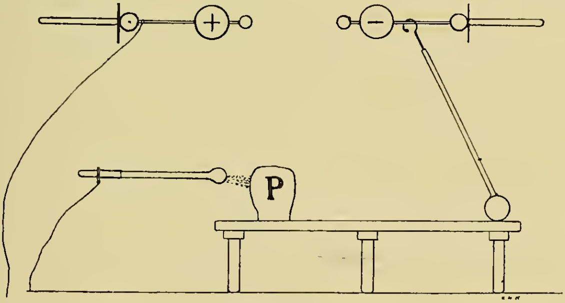

Fig. 11.

Diagram of the Static Brush Discharge.

A powerful static machine, such as has already been described, must be used, the negative side being connected to the patient or platform and the positive to the earth. The sliding rods are drawn apart as far as possible and the machine started. It is as well at the beginning and at the end of the treatment, when the current is being applied to the patient, to put the electrode to the platform, thus shortcircuiting the current. It will be found to add to the comfort of the patient. This should be done also if the treatment has to be interrupted.

It will now be seen that the violet discharge passes from the electrode to the platform or patient, whichever is the nearer. The power of the static machine and the condition of the electrode should be such that the discharge will take place at a distance of at least 10 inches, but this discharge may, with a powerful machine and favourable conditions, be 12 to 15 inches.

At a distance of 10 inches the patient will feel little or nothing, and may describe the effect of the current as a cool wind. But if the tip of the electrode be brought to one-fourth of the distance, the patient will complain either of the little sparks which pass, or of a sensation as if a blast of hot sand were being directed upon the spot. Now a point midway between this distance and the greatest distance at which the current can be made to pass is the usual distance for most therapeutic purposes. Practically it will usually be found to be about 4 or 5 inches from the end of the electrode to the patient's skin.

It is of importance that the skin should be bare, for several reasons. If the current be given through any clothing, the effects of the ultra-violet rays and the ozone are lost; but of more importance is it that the clothing acts as a separate capacity, and some of the electrical effects are lost. Clothing also acts as a condenser, and the current in passing through it is therefore intensified, which may not only damage the skin but may set fire to the under-garments.

The patient should be placed on the platform opposite the negative pole, otherwise there will be a tendency for the current to pass from the positive prime conductor to the patient, which will give rise to a prickling sensation, or, if the distance be short, to sparks.

The electrode must be kept constantly moving, or, alternatively, the patient must constantly move the part under treatment, otherwise too severe an effect will be produced, and blisters and burns may result.

Though it is quite possible, and even reasonable, to assume that as far as direction of current is concerned, it may be said to flow in one direction or another, yet we might more properly speak of currents, some of which are flowing in one way and some in another, and that when we speak of current flowing in such and such a direction, we really mean that the majority of currents flowing are flowing in that direction rather than that there is a complete uniformity of flow, or absolute unidirection of current.

The physiological effects of this current are various. There is a certain antiseptic action from the ultra-violet, violet, and blue-violet rays, as well as from the ozone. The presence of the ozone can be demonstrated by means of the experiment above described (p. 23), and the tanning of the skin which follows repeated applications is evidence of the presence of the ultra-violet rays. It is this antiseptic effect which is of value in the treatment of abscesses or of open wounds. But of more importance from a therapeutic point of view is its action in causing a fine vibration in the deeper structures, thus relieving local stasis, diminishing induration, and aiding in the restoration of a normal circulation. When applied to the unbroken skin, after a transitory vaso-constriction, a well-marked vaso-dilatation occurs, and then a few minutes later an evident rubefacience is established. This again aids in relieving local congestion. Its effect is very dramatic when applied to the swelling associated with recent sprains or fractures, relieving the swelling; hence the pressure is reduced, and with it therefore the pain is relieved within a very short time. Furthermore, the action of the static brush discharge not only relieves the local congestion, but so stimulates the tone of the arterioles that a complete relapse is unlikely. Perhaps one of the greatest uses of this current is its application to the spine in cases of neurasthenia (to which a chapter is devoted). Its action, if pushed, is that of a counter-irritant, but it is not of much use for this effect.

The duration of each application of this current varies according to the size of the area treated and the effect that is required. For its antiseptic effect in conjunctivitis a few minutes' treatment is ample, but where there is the whole length of the skin over the spine to be reddened, twenty minutes to half an hour will be occupied in getting the desired result, when the patient will be warm, sometimes gently perspiring, with a tendency to drowsiness, followed later by a desire to sleep. If the current be applied longer than the time stated (and in some cases I have found even fifteen minutes sufficient), the patient will complain, not only of the effects noted being present in an exaggerated condition, but also a sense of fatigue. A type of case in which this current is useful is acute gout; and in fact almost any pain which is so acute that the part cannot bear to be touched will be soothed. The feeling of the current is grateful to the patient and the effect satisfactory.

CHAPTER VI

THE HIGH POTENTIAL GLASS VACUUM TUBE CURRENT

This is a convective current derived from the negative side of a static machine and administered by means of glass tubes of different shapes and sizes, of varying vacuums, and provided with one terminal or none. In this latter case the tube is held in a brass holder which is attached to the prime conductor. When in action the tube lights up with a stream of colour, varying with the blue-violet of a low vacuum to the yellow opalescence of a high vacuum. When the electrode touches the patient the stream will be seen to direct itself to the point of contact.

This stream is the cathode ray, composed of electrons which, Sir Oliver Lodge asserts, pass through the glass. In the same paper by that authority occurs such an illuminating paragraph that it is quoted in full: "It is from these rays (the cathode rays) that most of the others are derived. It is owing to a study of their nature that so much advance, almost of a revolutionary character, has been made recently in the science of electricity. The cathode rays are flying electrical particles called electrons—actually particles—I cannot say particles of matter, because they appear to be particles of which matter is composed—they are particles of electricity. We now know that electricity is really an atomic thing in the sense of having actual particles, and these particles are called electrons. They fly along in the cathode rays. Their motion constitutes all electrical currents. They go round in magnets, and are in fact the substitute, the substratum of the whole electric science. When they are intercepted they give rise to radiation; when they revolve they also give rise to radiation. It is their acceleration which excites all radiation, and when they are suddenly stopped, as when impinging on a solid target, they give rise to X-rays.

Whenever you have these flying electrons, these cathode rays, sometimes called Beta rays (where they constitute one variety of radiation from radium)—wherever you have these rays striking and stopped suddenly—the X-rays take their origin."

The technique of the high potential glass vacuum is as follows: The insulated platform may or may not be used; its use, however, increases the intensity of its effect. The terminal balls being in apposition, the positive side of the machine grounded, and the negative connected either directly to the electrode, or to a metal handle in contact with it, and the electrode touching the patient, the machine is started and gradually worked up to a fair rate of speed, for we have

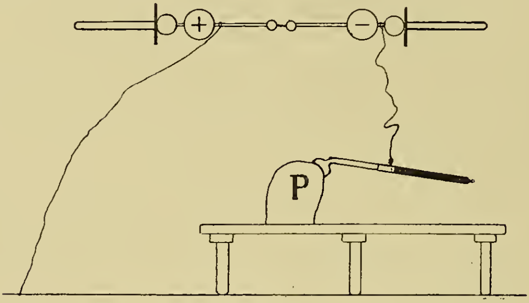

FIG. 12.

Diagram of High Potential Glass Vacuum.

not always, as in the static wave, the need for slow sparks at the spark-gap—rather the contrary. When this is attained the terminal balls are cautiously separated, a distance of half an inch is quite enough with which to begin. The patient feels nothing, or perhaps a sensation of heat. This heat is not due, or in only an insignificant degree, to the passage of the current through the tissues, but is produced by the heating of the glass from the passage of the electrons, and to the chemical action of the discharge upon the air spaces surrounding the electrode. There is no necessity for the use of Leyden jars in the production of this current. The vacuum tubes are adapted to the rôle which they are destined to fulfil; many of those depicted here are designed by Snow, and will be found convenient for special applications. Those without wire are less liable to puncture and appear to be preferable.

Perhaps the most valuable effect of this current is its power of restoring healthy secretion to skin and mucous membrane where it is deficient. In acne it is almost a specific; here too its antiseptic action may be effective—a skin that has been rubbed for five or ten minutes with a glass vacuum tube in action has a most distinct ozonic odour. Rectal ulcer and simple fissures are markedly benefited, though in these cases if relief be not obtained in the first three or four treatments it is probably useless to continue (Fig. 13).

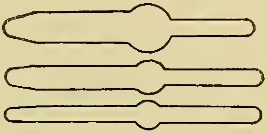

FIG. 13.

Glass Vacuum Electrodes (Dr. Arnold Snow's).

In some forms of hæmorrhoids its action is excellent; acute capillary piles are invariably relieved at once with the disappearance of anal spasm. Externo-internal piles without marked hypertrophic changes are greatly improved and often entirely cured; postpartum piles with partial prolapse are favourable cases for this treatment. This current exercises no lasting good upon large venous internal piles (see Chap. XXII.), or where there is marked hypertrophic change. In those cases, if this current will do good to the hæmorrhoids, amelioration dates from the beginning of treatment, and where this does not obtain it is usually disappointing to continue it. In pruritus the application of this current is often very effectual, relieving the itching from the first (Fig. 13).

In chronic catarrh and in hay fever this treatment has had some success, and when it is considered that ozone is evolved, with its germicidal action, apart from any local vibration which the current sets up, the rationale of the improvement will be manifest (Fig. 14, 7).

In gynæcology it has been extensively used (a chapter is devoted to this subject), with striking success in some cases and equally indifferent results in others. Much of this discrepancy may be explained by and put down to either errors of diagnosis or improper use. For instance, an early vaginal catarrh is quite easy to cure with this current, but where the discharge is proceeding from a diseased endometrium it is naturally of little avail. In some cases of sterility without any apparent reason this current has so altered the nutrition of the parts as to bring about the desired result, or at any rate pregnancy has followed the treatment after years of sterility (Fig. 14, 2).

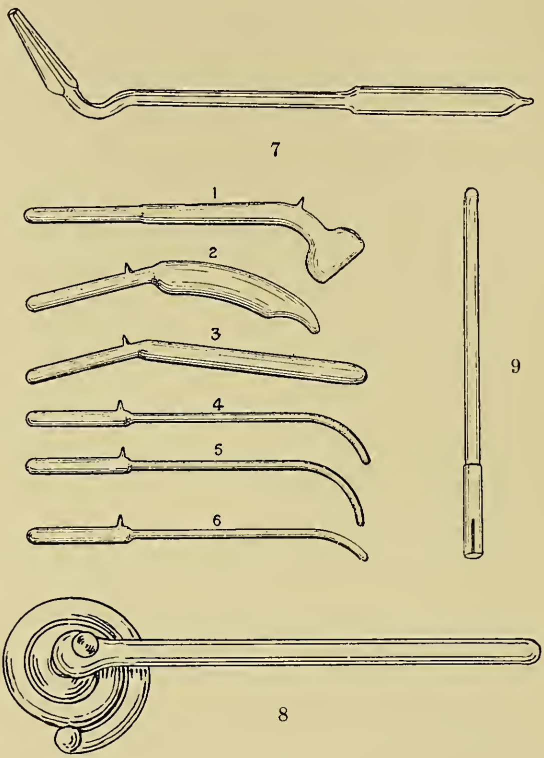

Fig. 14.

Various Glass Vacuum Tubes.

1. Small Surface Electrode.
2. Vaginal Electrode.
3. Rectal Electrode.
4. Urethral Electrode.
5. Prostatic Electrode.
6. Uterine Electrode.
7. Aural or Nasal Electrode.
8. Large Surface Electrode.
9. Handle.

This current has a most excellent effect upon the vocal cords. It is applied with the surface electrode to the outside of the throat, for about twenty minutes. Public speakers and singers find great relief when their voice has been overstrained; or if they have been using the voice when the cords are congested, the voice gets clearer after treatment. It has been asserted, I think by Snow, that it increases voice range, and in one perfectly healthy singer, during treatment the voice did add one half tone each way to its register. In lupus vulgaris and tubercular ulceration an improvement can usually be readily produced, but my experience in these cases does not allow me to speak with any assurance. In such cases the brush discharge is preferable.

To physicians who are accustomed to high frequency applications this current will come as a familiar acquaintance, and results which they obtain when the vacuum tubes are excited from the coil will give equally good results when attached to the static machine, and a careful comparison will show that the application is more pleasant to the patient when derived from the latter. This may be readily demonstrated by applying the surface electrode to the forehead, using the same electrode, but exciting it first from the coil, and secondly from the static machine, when it will be found that there is a point at which a distinct sense of pain is felt when the coil is used, which is not present with the static high potential glass vacuum tube current.

CHAPTER VII

STATIC SPARKS

Even older than the history of the Brush Discharge is that of Sparks. It is the oldest form of static electricity on record, and dates from 1734, when the Abbé Nollet first used the static spark as a therapeutic agent. Benjamin Franklin, John Wesley, Charcot, or perhaps Vigoreau his assistant, Morton, a student of Charcot, and Snow, who have brought them down to the present day, have both made use of them and written about them.

Contrary to the usual case of sensations produced by static, and most modern electrical methods, the spark cannot be called pleasant. It is painful, therefore it is fortunate that it is not often necessary to use it, and when we do use it, it is in cases of paralysis where sensation is deficient, or in those of severe pain, where it gives such instant relief that it is the patient rather than the doctor who insists on repetition.

There are, and have been, several kinds of sparks used as therapeutic agents; the Static Indirect, the Static Direct, the Static Friction, the Leyden Jar Spark, and the Resonator Spark. The first only will be described, the others being too severe for modern use, with the exception perhaps of the resonator spark, which is a short spark derived from a coil or a static machine, the current being led through Leyden jars and a resonator. The chief use of the resonator spark lies in its power to produce a hyperæmia of the skin, which is maintained for some hours. I have used it with moderate success in cases of alopecia and the relief of obstinate pain in small joints, but the spark which I use mostly, and to which I am going to limit myself in this description, is the Static Indirect Spark. It is a true current, and may be compared to a spark being discharged from a Leyden jar, the patient representing the jar. The whole of the static charge of the patient is suddenly focussed to one point, by the grounded ball electrode being brought into proximity, and there discharged disruptively with the sudden appearance of sound and light. The spark is thus administered. The negative side of the static machine is connected by the shepherd's crook to that part of the platform which is as remote as possible from the patient; the positive side is grounded, the platform being as far away from the machine as possible, and the patient opposite to the negative.

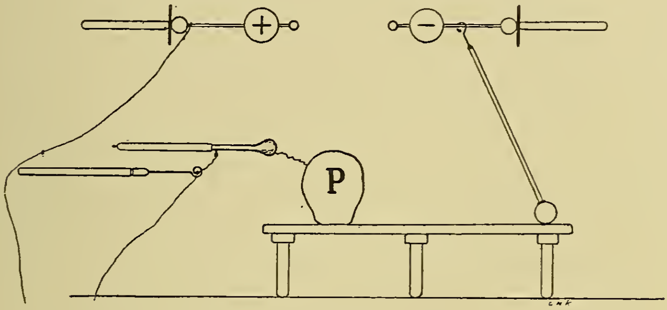

Fig. 15.

Diagram of Static Sparks.

Separate the prime conductors as widely as possible, and start the motor; then bring the grounded ball electrode near to the patient, and with a quick movement of the wrist swinging it past the part to be treated at such a distance that a single spark will pass. This distance will depend upon the output of the machine, the rate at which it is running, and the size of the ball electrode. The ground chain is supported in a chain holder. The administration of the Static Spark requires a little practice, and upon the skill of

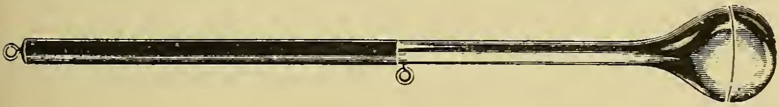

Fig. 16.

Ball Electrode.

the operator depends the minimizing of the discomfort to the patient; a patient will tolerate sparks with much greater equanimity if he knows when to expect them. So in giving a simple spark it is better to say "now I am going to spark you," or in giving several, to swing the electrode to some well-known air so that the patient unconsciously knows when to expect the spark. It is better that sparks should be given to the bare skin than through clothing; and in clefts of the body, such as the axilla, Snow's spark director will be found useful. The knob of the little instrument is placed in the cavity which it is desired to spark, and the ball electrode brought near enough to the projecting part A, which thus conveys the discharge to the knob in contact with the patient.

It has already been pointed out upon what the sparking distance, *i.e.* the length of the spark, depends. This length may be further modified if the operator move his foot nearer to, or farther from, the platform. Long sparks are indicated when the part under treatment is large, such as bulky muscles or large joints; then they may be 4 to 10 inches, according to the toleration of the patient and the skill of the operator; but to small muscles, such as those of the face, or to small joints, such as the phalangeal joints, half an inch will be all that is possible, and sometimes even this is too severe. Furthermore, the larger the part to be treated the larger should be the size of the electrode; a large ball delivers a heavy pounding spark, while a small one gives a lighter spark, but with a more biting sensation. It would naturally be imagined that when the whole electrical energy with which a patient is charged is suddenly focussed and discharged at one point, the agitation set up at that point, and in the parts below it, must be considerable. And this is what happens. There is a violent tissue contraction which drives

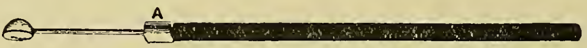

FIG. 17.

Snow's Spark Director.

out fluid from the tissues. This contraction is not merely transient but persists for some hours, and in the case of a spark of 4 inches or more, a mark is often left, resembling an old vaccination scar, which may persist for several hours. It is this contraction with squeezing out of fluid which causes the alleviation of pain, by relieving the pressure upon the nerve which is affected. The instantaneous soothing induced by fairly long sparks, 15 to 20 inches, well directed along the course of the sciatic nerve, is in some cases marvellous, and there is nothing so peculiarly adapted to remove deep-seated congestion as this method. Furthermore, not only is the pain relieved, but the muscular spasm which so often accompanies this—and other—pain is relaxed.

Another use for the static spark in neuritis, as in sciatica, is its diagnostic value. A patient will come complaining of pain along the entire distribution of the nerve; a series of short sparks, however, will show the exact position of the lesion: for whereas these sparks are, for the most part, only unpleasant, when they are directed to that part of the nerve where the lesion exists the patient will immediately complain of a sharp pain, so that when this procedure has been followed, treatment need only be directed to that particular part. The static spark will be found useful in the various forms of rheumatism, and of possible value in cord lesions. Its capacity for causing strong muscular contraction makes it useful in preserving the tone of a muscle whose power of motion is temporarily absent or limited, or in fact in temporary paralysis its effect is excellent. After a very short sparking a local and general diaphoresis will be noted, showing a constitutional as well as a local effect.

In deep-seated trouble in large joints, long sparks applied in the spaces between the bony processes, as on either side of, and below, the patella in the knee, will often effect relief when other measures fail.

CHAPTER VIII

THE STATIC INDUCED CURRENT

A good deal of misconception exists in the minds of many practitioners as to the nature of this current, which is often confounded with the Static Wave Current. This is due to the fact that both currents were brought to the notice of the Profession by Dr. W. J. Morton, of New York,—the static induced in March 1881, and the wave current in 1899. The wave current has already been described. The static induced differs in many particulars. It is not unidirectional; it needs the employment of Leyden jars, and its action is local rather than constitutional. To obtain this current a Leyden jar is attached by its inner coating to each of the prime conductors, and from the outer coatings to rheophores leading to metal electrodes which are placed on the mucous membrane or bare skin of the patient. This current may be represented diagrammatically thus:—

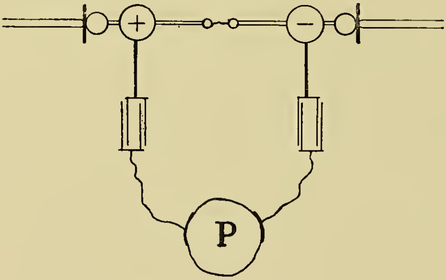

Fig. 18.
Diagram of the Static Induced Current.

The jars need not be of the same capacity; indeed, it is as well to have ready three or four different sizes of jars so as to suit them to the size of the part to be treated, as was first shown by Dr. Arnold Snow. The manner of administering this current is simple. The patient need not be placed on the insulated platform, but may be seated or lying on any ordinary chair or couch. The machine having been started at the slowest possible speed with the spark-gap closed, this should be gradually opened until the desired muscular contractions occur, or up to the toleration of the patient. What has been said in the chapter on the static wave current as to the terminal balls being brightly polished, and the electrodes being kept firmly in apposition, applies equally to this current. The average time for each application is likewise about twenty minutes.

The advantages of the static induced current are, firstly, we can get with an inferior or weak machine muscular contractions which we could not get with the wave current; and secondly, these contractions are obtainable without any general effect on the patient. As a rule, of course, the constitutional effect is an added advantage, but if for any reason we wish to omit it, then the static induced current lends itself for the purpose.

The local effects of this current are similar to those of the wave current, though results are as a rule better with the latter, which is to be preferred in the majority of cases.

The size of the jar needed depends upon the part to be treated and the area of the electrode; naturally, the greater the effect wished the larger should be the jar employed. If, for instance, in employing this current in constipation, the muscles of the abdomen are seen to be contracting too vigorously, a smaller jar should be used, or if the patient says there is no sensation in the rectum, the jar connected with the rectal electrode should be changed for a larger one.

The technique for this current in obstinate constipation is as follows: Snow's rectal electrode being used (as described in the chapter on the Static Wave Current), it is connected with the outer side of one of the jars (polarity with this current is immaterial), usually the smaller one, while a large abdominal metal pad is connected to the other; the current is then turned on as already described.

It is in cases of obstinate constipation that it will be found most useful, and in certain cases where pain is present and perhaps where large electrodes have to be used the current may be tried; but, in general, while it should not be forgotten, it will be seldom employed, especially when the static machine is a powerful one and all is working well.

CHAPTER IX

THE STATIC WAVE CURRENT

Of the currents derived from the static machine the one in most general use and the most useful is the Static Wave Current. It is also known as the "Morton Wave Current," as it was first introduced by Dr. Morton, of New York, and christened by him (in his paper read before the American Electro-Therapeutic Association, September 23, 1900) the "Wave Current," because in the completion of its circuit Hertzian waves emanating from the patient's person are produced.

The platform (Fig. 19) should be 5 feet by 2 feet 4 inches in size; many that are sold are far too small and not sufficiently insulated. Even with long glass legs, 9 inches to 10 inches, and these placed in glass castors, so that the platform is 13 inches from the ground, the insulation is not always perfect, and it seems a pity, having obtained a powerful current, to allow it wastefully to escape. In damp weather the legs should be rubbed dry with a hot cloth (and indeed all moisture should be removed from any part of the platform). The edges of the platform should be rounded and bevelled and polished or varnished, but its surface should be sand-papered, so that, while smooth, it is not polished as it will probably come from the manufacturer's

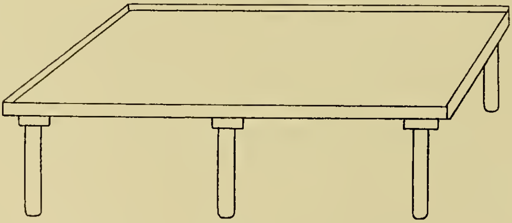

Fig. 19.
Static Platform.

hands. The platform should be placed 3 feet or more from the machine, or from any of the surrounding objects.

The size, shape, &c., of the electrode depend upon the part to be treated. It matters little what is the material so long as it is of good conducting quality. Sheet-lead, which may be cut with shears to the required size and rounded on to the part to be treated, is very suitable. Bottlecap composition, which is a mixture of lead and tin and procurable in any thicknesses, is even better. Either this or the lead is convenient for the treatment of lumbago, sciatica, knee joint, stiff neck, and so forth.

Dr. Curtis Webb coats these metal electrodes with modelling clay, which he keeps moist by having it wrapped up in wet butter-cloth. By this means very perfect apposition is attained.

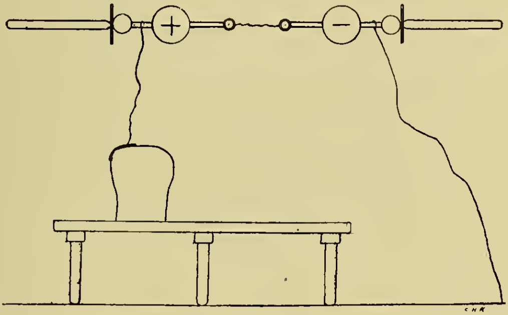

Fig. 20.

Diagram of Static Wave Current.

Small joints, such as toes and fingers, may be bound round with metallic braid, or the foot or hand may be immersed in water in a porcelain or papier-mâché tub into which a metal electrode has been led.

Special electrodes are made for use with this current for the treatment of constipation (see p. 50), enlarged prostate (see p. 131), dysmenorrhœa (see p. 131, Fig. *a*), subinvolution (see p. 197), &c.

The patient being seated on the platform, and whatever electrode has been selected being placed in close apposition to the skin or mucous membrane, and connected with the positive sliding terminal by means of a copper wire; the negative sliding terminal is similarly attached to a good earth connection. The terminal balls (brightly polished) being closed, the static machine is started, and the operator, standing on the grounded side of the machine, very slowly draws out the sliding rod, thus gradually separating the terminals. Sparks will flow between the terminals, forming a spark-gap, which should be increased up to the tolerance of the patient. The length of the spark-gap is governed by the size of the electrode and the sensitiveness of the patient, and also by the relative humidity of the atmosphere. The electrode should be kept in close apposition to the part treated. This may be done with a bandage, a cushion, or, what I have found useful, an ordinary hot-water bag. Any clothes or linen underclothes between the electrode and the patient cause a burning sensation, due to the current passing in the form of short sparks through the obstacle. If the skin itself, in actual contact with the electrode, be very dry, it is well to moisten it or the electrode with a little soap and water. After the current has passed a short while the skin becomes moist and allows a larger volume of it to pass through. It is advisable for the patient to remove articles containing metal, such as hat-pins, hats with metallic foundations, any parts of the dress which may have metallic braid or gauze upon them, because a current is induced at these metallic points which materially interferes with the comfort of the patient. Summing up the points of technique, we have—

(1) An efficient static machine.
(2) A sufficiently insulated platform.
(3) A suitable electrode in close apposition.
(4) Removal of metallic clothing.
(5) A direct grounding attached to the negative side.
(6) The patient connected to the positive side.
(7) The gradual opening of the spark-gap.

One point to be especially noted, which is essential in the administration of this current—for on it depends not only the comfort of the patient but the success of the treatment—is the rate at which the sparks cross the spark-gap. If they flow too rapidly a useless and almost unbearable tetanic contraction of the muscles is induced, while, if too slowly, the contractions are not sufficiently numerous for the therapeutic effect; they are usually irregular and provocative of discomfort. The appropriate rate will vary within certain limits according to the area of electrode, and the sensitiveness of the part under treatment; as a general rule about 200 sparks to the minute will be found most effectual. The size of the terminal balls has much to do with the rate of interruptions, and for this purpose it is well to have three sets varying from ½ inch diameter to 2½, but as this varies with other conditions besides the rate of spark flow, there must be other means for the regulation of this.

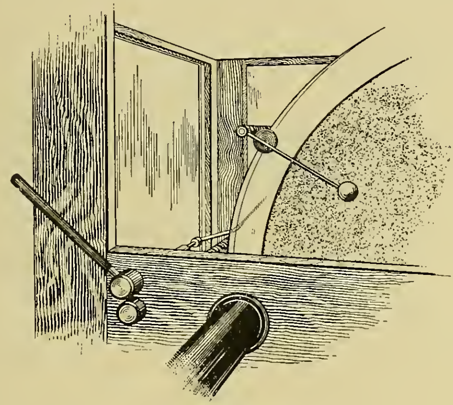

Fig. 21.
Baker Field Regulator.—View *a*.

In the most modern type of static machine this is accompanied by a patented device known as the Baker Field Regulator; it consists of a metallic arm electrically connected to the main collecting combs, so supported to and by an insulated rubber arm extending through and to the front of the cabinet that, by the use of a lever on the front, it may be raised or lowered to or from the field comb as shown in the accompanying illustration. This particular construction illustrated operates in the following manner. When the machine is generating and the arm is down next to the main comb the fields are allowed to charge to full saturation, but if the arm be brought near to the field the current from the inductor is allowed to pass in proportion to the resistance in this circuit to the main combs and out through the discharge rods. While this will decrease the amperage or volume of current flowing, it does not materially affect the voltage.

There is one of these regulators on each side of the machine. This device is particularly useful for static wave current, inasmuch as current can be regulated from practically no current to the maximum output of the machine without losing its voltage value. It gives the spark in static wave current a much steadier value of the slow, rhythmic character so essential to this form of static electricity.

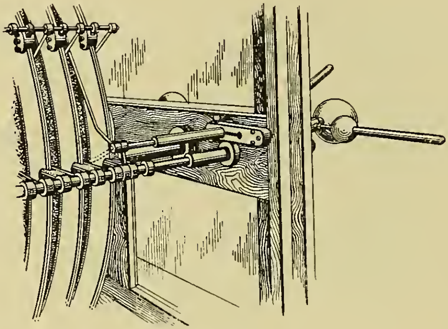

Fig. 22.

Baker Field Regulator.—View *b*.

But for those who have an older type of machine the most effectual way in which the frequency of the sparking between the prime conductors may be controlled is the method of Dr. George Starr White, of New York. It is very simple and any one can make the necessary attachment. All that is required is a brass rod ending in a small ball or point; this end is placed outside the machine touching the screw head A, which bolts in the cross rod supporting the neutralizing combs. It is supported by the screw heads bolting the machine together, or by screw heads placed in suitable position, BC. This rod is connected to the negative prime conductor, which, it will be remembered, is properly earthed. All that is necessary to do to control the speed of the spark is to draw out the rod so that the distance between its point and the screw-cap of the neutralizing comb becomes greater or less: the farther out it is drawn the more rapid will be the flow of sparks, and *vice versâ.* With a little practice control over the spark frequency is easily obtained. For further detail of this particular method see *Journal of Advanced Therapeutics,* March 1910, page 124, "Controlling the Spark Gap of a Static Machine," by Dr. G. S. White. Another method to be used alone or in conjunction with the above is to place a chair near the platform, and move this nearer or farther so as to regulate the current to the desired rate.

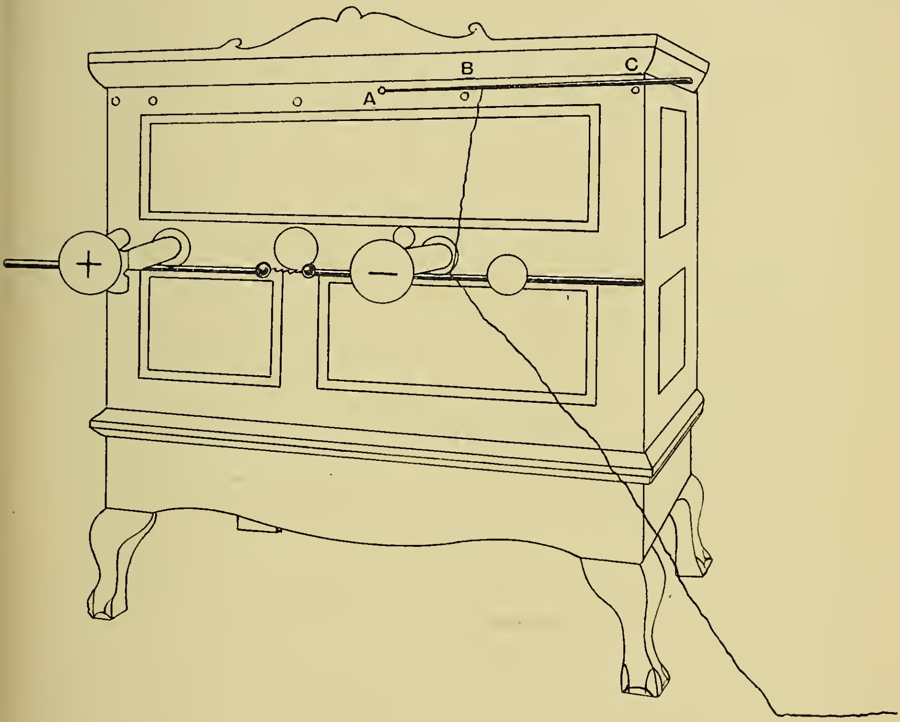

FIG. 23.

Retarding Arrangement for Slowing the Rate of Spark.

Sometimes the machine will even then be generating so strong a current that the spark cannot be slowed down to what is required. In this case I have found it useful to hold the pointed brass electrode (which comes with all Static Machines) in one hand, attached to a good ground connection, and to direct the breeze discharge to such a portion of the platform as will let enough current leak away for the spark rate to slow down; by this means it can be so slowed that it can be made to stop altogether.

The average time for the application of the current is twenty minutes. In some cases during the last five minutes, instead of keeping the spark-gap at its maximum, the rods may be gradually opened and closed so as to produce a surging effect. The current then, starting from zero, gradually swells to a maximum and returns to zero in the same way, thus contracting and relaxing the tissues beneath.

Turning now to the indications of this current. When properly applied there is a local vibratory effect, and muscular contraction takes place; local congestion is relieved, secretion is increased, and local pain is modified, either wholly or in part.

It is indicated in almost every case of inflammation, either acute or chronic; the presence of pus, however, distinctly contra-indicates its use. Inflammation is accompanied by congestion or stasis, and it is this stasis which is relieved by the successive contractions produced by the current. It is readily understood how wide a range of influence is possessed by these currents. Of the diseases in which they are frequently used, let us take for an example neuritis, such as sciatica. Here we have an increased vascularity, a multiplication of tissue elements, and the presence of migrated leucocytes within the nerve-sheath pressing on nerve-tubules, giving rise to pain. With the current properly applied, tissue contraction takes place and the leucocytes are squeezed out, and the congestion is relieved; hence relief is obtained from the pain. A typical case is as follows: Dr. E. W., aged about 50, had a history of frequent attacks of pain radiating down the length of the sciatic nerve. This had extended over a period of four or five years. During the last six months there had been almost constant pain in the calf of the leg, which had interfered with the patient's walking, his working, and his sleep. I applied the wave current from a powerful influence machine (four-tenths of a milliampere and 750,000 volts), preceding it with a short administration of light from a high-power incandescent lamp. The metal electrode covered most of the gastrocnemii, the soleus, and the peronei. The current flowed for twenty minutes, at the end of which time patient felt his leg to be much lighter with little or no pain in it. This was on November 18; on November 20 he came again and reported that there was a very considerable diminution in the severity and duration of the pain, and that he had had two good nights, and that it was a pleasure to wake up in the night to realize that he was free from pain. The treatment was repeated. On November 22 he reported continued improvement with pain only now and then, with long intervals of freedom. Treatment repeated. On November 26 there was hardly any pain; his improved walking was the subject of comment amongst his friends. I think he has had no treatment since then, and has had no return of the pain.

Its use in myalgias, such as lumbago, in synovitis, and other diseases is described under chapters on those diseases.

Dysmenorrhœa is another disease in which the wave current is most useful. Here it may be administered by means of an electrode having a metal bulb placed upon an insulated rubber handle. The patient should be instructed that the bowels should be freely opened before commencing treatment. The patient, being placed in Sim's position on the reclining chair with her back to the machine, the electrode is lubricated and passed into the rectum, following the sacral curve, and pressed against the uterus. The handle may be held by the patient or maintained in its position by means of an X-ray tube-holder, or the current may be administered by means of a piece of block tin, or metal composition, about 22 gauge, measuring 4 by 6 inches, and placed over the lumbo-sacral region. In either case the electrode is, of course, attached to the positive pole, the negative being grounded. The spark-gap is gradually increased to the tolerance of the patient, but not producing any pain, a painless pulsating sensation being all that is experienced. The duration of the treatment should be about twenty minutes, and in very obstinate cases should be given daily for the first month, three times a week during the second month, gradually decreasing the treatment with the increase of comfort at the time of menstruation. If after fair trial of this method the relief is not satisfactory, it is certain there exists some pathological condition beside congestion, and the case has become one for the surgeon. A typical case is as follows: Miss D. P., aged 26, complained of having painful periods, each lasting a week at a time. The pain began with the flow, which was scanty, and lasted over a week, the patient having to go to bed for most of the time, the greater part of most days. Here dysmenorrhœa dated from childhood. All sorts of medicine and treatment had been tried without avail; the only thing that had given temporary relief had been leeches applied just before the period. Treatment was given as already described. Period came on a day before the usual time, with much less pain, and patient did not stay in bed after the second day. The flow was much freer and unaccompanied by headache. Flow ceased on the fifth day and patient felt quite well, instead of feeling slack for several days. There were nine treatments during the next intermenstrual period, which, when it arrived, was less painful than last time. In five months' time patient had painless menstruation. That was several years ago, and patient has remained well ever since.

I could quote many more cases, but they all bear a great similarity one to another. Given a case of dysmenorrhœa when there is nothing abnormal on examination (except, possibly, a uterus abnormally anteverted and not fully developed), the pain should always be relieved by this agent; the pathology in these cases being that the endometrium has become congested and hyperæsthetic, causing a spasm of the uterine muscles, particularly at the internal os. At each monthly period the added physiological congestion increases the pressure and spasm, and hence the pain. With the contraction caused by the current passing through the electrode pressed against the uterus, the congestion is dispersed and the spasm relaxed.

The mechanism is similar in prostatic hypertrophy, and the electrode similar, only that the bulb is hollowed out to accommodate the enlarged prostate. This method is only of use in the cases of congestion, acute or chronic, which, however, constitute most of the total number. In the fibroid and fibromyomatous variety this treatment is not satisfactory, for, however well the alternate contraction and relaxation may squeeze out the secretion from the acini, remove the passive congestion, and stimulate the muscles, it cannot be expected to remove fibrous tissue. Relief will occur within the first six treatments, often earlier, and patients will frequently remark that they have lost the dragging-down sensation at the end of ten minutes of the first treatment.

Another condition in which this current with the rectal electrode is of striking service is chronic constipation (see also p. 39), in which there exists—either as a cause or a concomitant—a weakness, atony, or paresis of the muscular coats of the intestine.

Dr. Sloan, who was then President of the Electro-Therapeutic Section of the Royal Society of Medicine, in his opening address to that Society in 1910, bore striking testimony in regard to this. I think he reported 100 per cent. benefited, and remarked that the treatment was a revelation to some of the patients, in two of whom constipation was absolute.

My own experience has been most satisfactory. In 1904 I read a paper on static electricity before the medical society with which I was then connected, and mentioned in it the results I was then having. At the close of the meeting Dr. N. B. E., aged about 70, came to me asking me to undertake his cure, though he was very sceptical. Here, as in Dr. Sloan's cases, mechanical means had to be employed to empty the rectum, and medicines and diet had proved of no avail; constipation had existed for fifty years. I cannot recall the number of treatments he received, but he noticed benefit within seven days, and at the next annual meeting bore testimony to the efficacy of the treatment, saying that he was getting no treatment at that date, taking no medicine, but getting a daily evacuation of the bowels. This improved condition had lasted up to December 1908, when I last saw him.

The rectal electrode for constipation which I use was devised by Dr. Snow, of New York, and may be seen to vary somewhat from those used for prostatitis and dysmenorrhœa.

In only very obstinate cases have I had to resort to the static-induced current (see p. 39).

In sprains the relief afforded by this current is exceedingly striking. Relief from pain and power of movement are obtained within half an hour. Mr. S., a dental surgeon, sprained his ankle nine days before coming to me. He complained of much pain in walking, especially along the tendo Achillis, and that he could not stand at his work owing to the pain; after two treatments he telephoned me that he could walk for four or five hours without pain. Colonel K., leaving me after a treatment for another trouble (synovitis with effusion), sprained his wrist getting out of a motor-bus. His hand was useless on arrival, he had been unable to sleep on account of the pain, he could not shake hands or button or unbutton his coat, the hand was swollen and exquisitely painful. After twenty minutes of the wave current he could use his hand to button his clothes, and the pain was no longer acute. The next day he reported a good night, the pain was then limited to an area the size of half-a-crown, and the patient could use his hand with only a certain amount of tenderness. He shook hands on coming in and easily lifted a heavy candlestick.

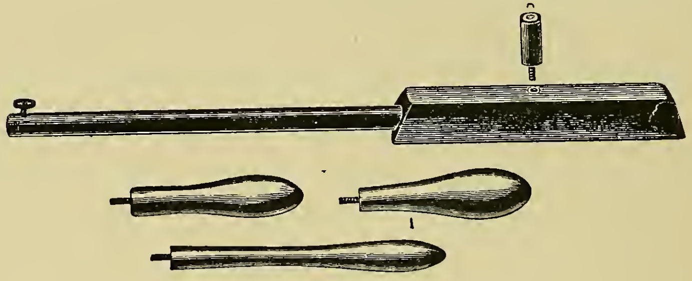

FIG. 24.

Snow's Rectal Electrodes.

In locomotor ataxia the application of the wave current has accomplished results when nothing else seemed of any avail. Pain is relieved, the ataxic gait is improved, the progress of the disease is arrested, and the general condition of the patient is altered for the better. The current, however, makes no difference to the Argyll-Robertson pupil nor to the knee-jerks. In June 1909 I saw Mr. B., a stockbroker, aged 46. His history briefly was this: About three years ago, while washing his face, he noticed he could not stand. Soon after he began to have lightning pains, and was told he had locomotor ataxia. This was confirmed by several eminent specialists. When I saw him the case was typical: he had the significant gait, the Argyll-Robertson pupil, his knee-jerks absent, and Romberg's sign was very distinct. He complained chiefly of the pain, of which he gets attacks utterly incapacitating him, and lasting seven or eight days. From the beginning of the treatment the pain decreased and his general condition improved. On August 19 he had had twenty-three treatments in all. He had not been one day without attending his business, but had some very heavy work in front of him and wished to suspend the treatment to see how he could get on without it. He returned on October 4, saying he had been one of two doing the work of five men, but now had some circumflex neuritis; this was cured in two or three days. I saw him with his doctor the other day. His doctor remarked how very much better he was walking, and the patient said he had not been laid up since he came, and was very busy, but would come back to me if ever the pain returned.

I could quote many and varied cases in which I have obtained results with the aid of this current—cases of enlarged spleen reduced to one-third of the size by this treatment, cicatrices rendered less adherent, the pain from pleuritic adhesions relieved, other cases of such varying nature as rheumatoid arthritis, infantile paralysis, dyspepsia with dilatation of the stomach—in all of which I have proved the utility of the wave current.

CHAPTER X

INCANDESCENT LIGHT AS A THERAPEUTIC AGENT

In the treatment of cases by the newer varieties of therapeutic agents, very little is heard in Europe of the high candle-power incandescent light being used as a curative measure. And yet it holds a high place with those who are accustomed to use it in the course of their practice.

Light is, as we know, a widely extended necessity to the life and well-being of cell development and sustenance. Without it proper metabolism is impossible, and when scientifically applied in suitably selected cases it will do more than any other one thing to restore normal physiological conditions.

The light which I have been in the habit of using is a very simple affair, being nothing more than a 500 candle-power incandescent electric globe, with a carbon filament, which carries about 12/15 amperes of current.

One point should be noted in the description of the apparatus. The lamp must be a *single* carbon filament capable of carrying 12/15 amperes, and not several smaller lamps, which in the aggregate give the same candle-power. The quality of the light varies with the intensity of the producing force, whilst the heat emitted is always the same in quality, varying only in amount. The average wave-length of the light varies with the current-strength; as this increases, there is an increase in the luminous rays, partly in the luminous (yellow-green) frequencies, but with an even greater increase of the blue-indigo-violet frequencies. These frequencies are not increased in direct proportion to the amperage, but by arithmetic progression. Moreover—and this is a point of practical experience—a cluster of small lights, though it amounts to 500 candle-power, and even more, will not produce the effect of the single filament carrying the larger amperage. With the cluster thermic rays may be produced, and with their production some measure of therapeutic good obtained, but when these lamps, or clusters of lamps, are deprived of their thermic energy their effect is nil. Photo-therapy, in contra-distinction to thermo-therapy, means the presence of yellow-green and blue-indigo-violet rays, and to obtain these a large amperage must pass through the filament.

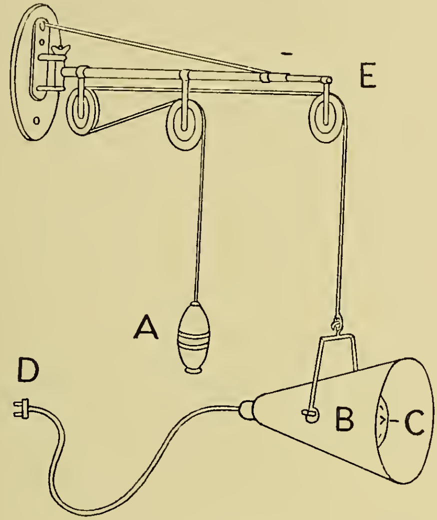

FIG. 25.

High Candle-Power Incandescent Light.

A. Counter-weight.
B. Metal Hood.
C. Globe carrying Incandescent Filament.
D. Plug for connecting with the main current.
E. Iron Bracket.

The globe carrying the incandescent filament is surrounded by a bright polished metal hood, the whole being swung on an iron bracket, and having a counter-weight, so that easy movement in any direction is readily obtained.

The method of applying the lamp is to sway it slowly backwards and forwards over the affected part.[1] The distance between the skin of the patient and the lamp depends a great deal upon the toleration of the patient, and this toleration in its turn will vary with the severity of the pain which causes the patient to seek relief, and with other modifying conditions. The light, in all cases, must be applied directly to the skin and as close to the bare surface as the patient will endure; little good can be accomplished if the light pass through any clothing, however diaphanous.

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[1] An automatic swinging apparatus is on the market, which relieves the operator of the work hitherto involved in the manipulation of the lamp.

The application is not painful, but the heat from the lamp is apt to become unpleasant. This may be obviated by immediately swinging the light away on the first complaint of the patient, or by brushing with the hand that part of the surface which is being treated.

The number of applications, their frequency, and the duration of the whole treatment depends so much upon the amount of pathological change present in each individual case that no time-limit can be laid down. The physician must be guided by the result obtained.

In cases of pain, if the pain can be relieved and held in check by one daily application until it disappears entirely, then daily applications are indicated. In some cases, however, at the beginning the applications may have to be twice daily, but in others thrice weekly will sometimes suffice. A case of simple acute lumbago may be expected to clear up in a few days, while a case of sciatica of years' standing may take several weeks. As a general rule, the longer the duration of the complaint has been, the longer will it be necessary to continue the treatment—*i.e.* the longer it will be before the pathological condition which is causing the trouble will be replaced by the physiological healthy state.

There should be no sense of fatigue or depression following an exhibition of the rays. For this reason, the first application should be of less power—*i.e.* the lamp farther away — and should be of shorter duration than the full therapeutic dose. Careful attention to effects produced soon determine the dosage in the individual case, but fatigue or weariness after treatment is the re-action of over-stimulation, and is an indication of too long an exposure. The length of treatment may be from ten minutes to half an hour. The production of hyperæmia varies with different individuals, and the skin of some patients will be found to be hypersensitive to the treatment, so there is no doubt that this remedy forms no exception to the general principle which holds for many others that patients may show some idiosyncrasy with regard to it.

In general, a short, sharp application of the light is better than the longer application at greater distance.

The theory of the curative power of sunlight or of concentrated artificial light is not thoroughly understood. Some effects are obvious, such as the dilatation of the cutaneous vessels and the stimulation of the sweat glands. The deeper action may be due partly to this (for with the filling of the capillaries a depletion of other vessels must follow) and partly due to the resistance to the light energy. It is well known that, whenever energy meets resistance at any point, heat is generated at that point. Now the skin is a poor conductor of the heat, but it readily transmits light. This light in the deeper tissues meets resistance, otherwise it would be transmitted through the whole body; and it is, I think, at the various points of absorption that the light rays are transformed into heat energy. Apart from theory, clinical results obtained by the use of a high candle-power lamp would point to deep penetration. Cases of nervous dyspepsia with flatulence are readily improved. In one case, I remember, a patient who was suffering from this disorder had for several weeks had insomnia, which was caused by the flatulent dyspepsia. After two or three applications of the light the patient was sleeping well, and shortly afterwards the flatulence had ceased to trouble him. There must have been penetration deeper than merely through the skin, to have influenced the chemical action in the stomach, which was giving rise to the fermentation and flatulence, unless it may be argued that the dilatation of the superficial vessels relieved a congestion of the deeper parts, and so a better state of metabolism was promoted.

The physiological effects of this form of photo-therapy are pronounced and emphatic. They are due to three forms of energy:—

Radiant Heat.
Light Rays.
Chemical Rays.

and may be summarized thus:—

1. Dilatation of superficial vessels and glands.
2. Removal of venous stasis and promotion of normal circulation.
3. A bactericidal action on superficial germs.

And as a practical result of these principles we get:—

1. Relief of pain.
2. Restoration of functional activity both in the skin and in the deeper tissues.

It will be easily seen how broad a field there is for the clinical application of the high candle-power lamp, and how many indications there are for its use.

In the treatment of some skin diseases, notably acne, chronic eczema, psoriasis, tinea sycosis, syphilitic and other ulcers, I have found this succeed where other treatment has only yielded disappointing results. In pruritus the itching is often relieved from the first application.

The treatment of acne by this light is invariably followed by good results. Whether this is due to some atrophic action on the subaceous glands, to the bactericidal properties, to flushing the parts with blood and increasing the circulation, or to a combination to all of these, I am unable to say; but I have yet to see a case of acne which the exhibition of the light will not improve or cure, and never has there been any ill effect.

In the relief of pain I think this form of treatment stands pre-eminent in the armament of the modern electro-therapeutist. I venture to assert that where, after a scientifically applied exposure to this light, no relief is obtained, it may be taken that the case should be promptly referred to the surgeon. And there are some cases where the light will cause the pain to become more acute: this differentiates those cases of retained, walled-in pus, which have gone beyond the power of phagocytes and opsonins, and which call for immediate operative interference.

The cases of pain which are more particularly benefited are rheumatic and rheumatoid disease, sciatica and other forms of neuritis, lumbago, and the varying conditions which are classed under that generic term, and certain functional diseases of the digestive system, especially gastric irritability and pain.

In certain classes of neurasthenia and insomnia, the light passed up and down the spine for ten or twelve minutes, and then applied for a similar period to the abdomen, will produce marked relief, and eventually a cessation of all symptoms. In these cases a very good effect is obtained if a rather intense application of the light be made to the length of the spine, up and down for two or three minutes, and then the skin be rubbed with a flat piece of ice, five or six times, or sprayed with Ethyl Chloride for a few seconds, the skin then dried, and the whole process repeated for fifteen minutes. This should be done preferably one hour before the patient retires to rest. The effect is calming and soothing, and a restful night will often ensue.

In addition to its power of curing furunculosis and obstinate acne, the light will, in many cases, abort a bubo, or carbuncle, before the pus has formed in any great quantity. In these cases it is a great aid as a diagnostic agent, for if the pain be relieved within ten or twenty minutes, it may be taken that repeated applications will effect a cure; whereas if the pain becomes worse—and this will occur in the first few minutes—it is certain that nothing but the surgeon's knife will relieve the condition.

There are many other cases that will suggest themselves as being suitable for this method of treatment. Cases of congested liver will improve owing to the restoration to that organ of a better circulation. Atrophied glands and muscles under the nutritional effect of the rays gain in size and function.

But I should like to mention, with much diffidence, two other classes of cases in which I have obtained definite and satisfactory results. The first of these comprises certain abdominal pains, sometimes ill-defined and indefinite, and sometimes more distinct and localized pain over the region of the appendix. These I have known to yield in a most surprising manner when this lamp is carefully used; and I believe that there are certain cases of incipient appendicitis which I have aborted by the early use of this light. Also subacute, long-standing cases of pain which, though not severe, is more or less constant, can be relieved, and the patient be put into a condition of safety. Some of these cases depend on a chronic congestion which is relieved by the dilatation of the cutaneous vessels, and thus the way is prepared for the restoration of a better circulation.

The second class of cases, of which I speak with even more hesitation, is that of either the early or recurrent pleurisy of phthisis. Of this I have only had two cases, but in each of these two the improvement was most marked and the breathing became easier in the first half hour, and in both cases the trouble entirely cleared up without the patient having to go to bed, and so far as I know there has been no relapse. It must be admitted that two cases are not sufficient basis on which to form a definite opinion, but with new therapeutic agencies one is justified in mentioning results, even if only to stimulate further research on the same lines.

Other physicians have reported extraordinary success with the light in the building up of tuberculous patients, who during the course of its administration have obtained relief from cough, night-sweats, and raised temperature.

Fresh uses for the high candle-power lamp are being discovered from time to time. Light aids by a very natural process the action and favourable results of other therapeutic measures. As an adjunct to other forms of treatment it has proved most useful. As a prelude to the Static Wave current it would seem that it not only adds to the comfort of the patient, but enables the physician to administer a stronger current without discomfort, and to obtain a more permanent and satisfactory result. Used in conjunction with the vacuum tubes it seems greatly to enhance their value in skin affections.

Only as recently as July 1911 a paper was read before the annual meeting of the British Medical Association by Dr. Bailey, of the Sussex County Hospital, Brighton, on the use of a lamp in conjunction with ionization, and the very successful results he had obtained in cases of fibrotic deposits, thickening in or round joints, chronic rheumatism, and rheumatoid arthritis.

It would be difficult to dilate on the therapeutic value of the high candle-power lamp at sufficient length to do justice to the subject, since it would fill a volume by itself.

Light Baths

Before leaving this subject something should be said about the Incandescent Light Baths.

In them it is the thermic rather than its photo-therapeutic effect which predominates, but certain it is that perspiration can be more rapidly produced in an incandescent light bath than in a Vapour or Turkish bath at the same temperature.

The importance of a well-acting skin can hardly be overestimated, and to those who are unable to get their skin to act naturally by means of physical exertion, the light bath comes as a most salutary substitute. The escape of water and salts from the skin is of great importance, not only in eliminating poisonous material which if retained will surely give rise to disease, but when the perspiration is checked the respiratory and intestinal mucous membranes get overworked and tend to become diseased. There come feelings of indigestion, a tendency to "catch cold," "rheumatic" aches and pains, all of which may be traced back to the defective skin elimination.

Among the advantages of a light bath is the stimulating action of the light rays which induce a perspiration at a comparatively low temperature; 140° F. is quite sufficient, which is, of course, much lower than the heat of a Turkish or Vapour bath. The fact that the head of the patient is outside the bath enables him to be always breathing fresh air; also, the bath is individual to each patient, there being several switches so that the requisite quantity of heat can be readily adjusted and obtained.

Where possible I advise the installation of a light cabinet in the patient's house: to the gouty, the rheumatic, the overworked, the sedentary, it is almost a necessity, and to practically every one it is a luxury which militates against chances of ill-health, and may be regarded as a premium paid on a policy of health.

Here the general incandescent-light bath only will be considered: the local light bath for individual joints, in my opinion, is superseded by the high candle-power incandescent lamp for reasons already fully explained.

The light bath which I have found most useful is a cabinet measuring 5 feet in height and 4 feet in width. It is octagonal in shape and has 42 incandescent lamps of 32 candle-power each, carbon filament, set in vertical rows, 7 in a row, the lining of the cabinet being of some white polished material. This is preferable to looking-glass. The cabinet should be provided with a stool which can be raised or lowered to suit the convenience of patients of varying heights. It should be readily opened at the top, which should have an aperture for the neck, so that the head shall be outside the cabinet. The wood should be kiln dried (oak for preference), so that it may not warp with heating.

The bath which is arranged for the patients to be in a sitting position rather than reclining on a couch is preferable for two reasons: one is that after a bath the patient may feel a tendency to faint on rising from the lying to the standing position, and secondly, that should any tendency towards fainting occur, it will be readily noticed by the patient and the bath stopped, whereas when lying down what might be only a tendency in the sitting posture might readily be converted into a syncopal attack not noticed by the patient and allowed to continue.

The patient should sit on the stool with the bath closed up, and of course be uncovered. If he be covered with even a sheet of thin material, the effect of the light rays is in some measure lost.

The lamps may be of blue glass, not white glass dipped, if the patient is going to continue the bath for some time. I will not say with certainty what various effects are produced by glasses of various colours—certainly not all those which have been claimed. But I have observed that the blue lights are more sedative, while the ordinary white lights tend to produce some irritability and other nervous symptoms.

Uses of the Light Bath

A free diaphoresis is usually produced in about ten minutes or less, the thermometer reading 140° F. In the majority of people the same time spent in a room of a Turkish bath at that temperature would fail to produce a perspiration, so that there is little doubt that the light rays have a stimulating effect upon the sweat glands.

The mistake that is often made when giving a patient a light bath is that he is kept in it too long: frequently patients say that they were kept in twenty to twenty-five minutes, and felt utterly exhausted after it. There should be *no exhaustion* after a properly given light bath treatment; rather a sense of well-being and exhilaration, so that, taken after a hard day's work, the effect should be to banish fatigue and to make the patient feel that he could do another day's work or able to go out and enjoy his evening.

The time spent in the light bath should rarely exceed ten or twelve minutes, and is often less, the criterion being the first drop of perspiration which rolls to the floor. This should be the sign for the patient to get out of the cabinet and into a bath of water, the temperature of which depends very much on what the patient has been in the habit of using, 65° F. to 80° F. or 85° F. If the patient has been in the habit of taking cold baths, then let the bath following the light bath be cold: the effect is then at its maximum. But when the patient is unused to anything but hot water, then let the bath be 80° F. or 85° F.—after which he should dry and dress slowly (slowly to avoid perspiration breaking out again). There is no need to rest, and no danger of his catching cold; in fact, taking these baths seems almost prophylactic against catching cold.

If the patient knows he suffers from an unusually dry skin, and perspiration is provoked with difficulty, he may have a glass of hot water immediately prior to entering the cabinet, and place his feet in a foot-bath of the same.

It will add much to his comfort if a cold wet towel be placed on the patient's head, or if it be kept cool by means of a Leiter's coil. These are made of aluminium in Germany and of rubber in the United States—either pattern is convenient.

Apart from results depending on the rapid diaphoresis induced, the therapeutic effects of the light bath may be disregarded. Light to have a curative value must be employed otherwise, as I have shown elsewhere.

The chief use of the light bath is as an eliminant; for the permanent reduction of weight, for instance, the use of it is futile. One pound, or even more, it is true, may be lost by the patient while in the bath, but the next day, or in a few days at the most, the patient will have returned to his former weight.

But as an eliminant the light bath is of great value; in such cases where prolonged diaphoresis cannot be employed without risk, *e.g.* in some cases of cardiac disease, diabetes, or chronic nephritis; in auto-infection of chronic dyspepsia and constipation; in the toxæmias of those patients who are being poisoned with the toxins of fatigue either physical or mental; in the chronic toxæmia of chronic rheumatism, when the elevation of temperature stimulates the oxidation of proteid material, and the increased skin activity carries away the waste products; in the case of patients prone to gout, or to headache due to some form of poisoning, possibly alcoholic, acute or chronic.

In all of these classes of disease the light bath has a curative action, and as a prophylactic to any one leading the life of a latter-day civilization its value can hardly be overestimated.

CHAPTER XI

ELECTRO-THERMIC PENETRATION

Some years ago it was pointed out in New York that when a clinical thermometer was thrust into the knee-joint of a criminal but recently electrocuted, it registered a temperature several degrees higher than the skin over the joint. This fact is strikingly recalled in investigating the peculiar type of High Frequency currents which are now known under the title of Electro-Thermic Penetration, or Diathermy. This differs from the ordinary high frequency currents in that the voltage is less, being 2000 to 3000 volts instead of a 100,000 or more, whereas the amperage is much greater, being from 0·5 to 3 amperes. Even with currents of this intensity the patient feels nothing except the increase in temperature. Of course, the increased temperature has been noticed for a long time in high frequency currents; in fact, D'Arsonval himself noted this phenomenon, but in diathermic currents it is this heat which is the fundamental effect and the main factor in the resultant hyperæmia. This increase in temperature is greatest in the path between the electrodes, as has been proved by means of a thermometer introduced into animals.

Electro-thermic penetration is a procedure by means of which we are enabled to raise any part of the body to almost any temperature we choose, for its great advantage over applying heat to the skin by means of hot-air, compresses, thermophores, &c., is that the heat produced by these measures is to a great extent wasted by the bad conduction of the skin and tissues beneath, and much is carried away by the circulation of the blood, while, on the contrary, the oscillating electrical energy penetrates the body in the desired direction and intensity, and is converted into heat along the whole path of the current, corresponding to the conductivity and current density in the various parts of the tissues, so that the joint is warmed from within outwards rather than from without inwards, thus causing a flow of blood to the part and enlargement of the vessels as well as promoting tissue change, thus relieving pain, aiding absorption and secretion, and inhibiting the life processes of micro-organisms.

Until the discovery of this process it had not been possible to produce such a penetration of heat, for, being brought from without, much of it was absorbed by the skin, muscles, &c., through which it had to pass in order to reach the joint beneath.

With electro-thermic penetration, however, heat is produced in the depth of the tissues themselves by the electric energy which is consumed by their resistance, just as a wire is heated in the galvano-cautery or in the filament of an electric lamp.

It is possible to obtain by this method internal temperature higher than by any other means known at present, for the heat is generated so rapidly and in such a quantity that the blood-flow is no longer capable of carrying it off at once, and a prolonged hyperæmia is thus produced.

This type of current is essentially a high frequency current with the oscillations very much condensed—that is to say, the time between two consecutive oscillations is much shorter.

With the ordinary damped high frequency currents, such as are used for d'Arsonvalization and fulguration, the oscillations produced by the discharge of the condenser become rapidly smaller and smaller until they are extinguished, and a longer interval follows before a fresh discharge takes place and new oscillations are set up.

The length of these pauses or intervals is some very many hundred times that taken by the group of oscillations, about forty in number. It is evident that these pauses must considerably hinder any effects which the oscillations may produce. It is also evident that the electric effect must be greater as the pauses are made shorter and the groups of oscillations follow each other more closely. Were the interval without oscillations halved, the electric effect would be doubled, since there would be twice as many oscillations in a given time, and so on.

In the undamped current used for electro-thermic penetration these long intervals are done away with, hence we get a greater efficiency. The most satisfactory current is obtained when the duration of each group of oscillations is equal to the duration of the pause, thus:—

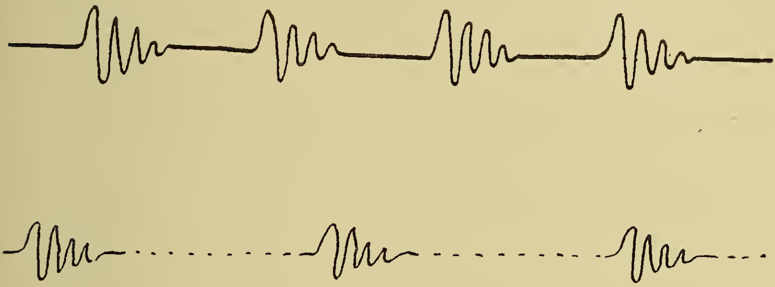

FIG. 26.

Oscillograms showing the Influence of Damping the Current.

The simplest form of apparatus for the production of diathermic currents is a static machine with small Leyden jars and a primary coil of an inducto-resonator.

In September 1910 I made several experiments of which the two following are typical—one with a potato and the other with a piece of steak. The electrodes were pieces of tin-foil, 2 inches by $1\frac{1}{4}$ inches, fastened to each end. Midway between the two ends was a hole into which was placed a thermometer.

Experiment with Potato.—Before the current was started the thermometer registered 70° F. When the current had flowed for a minute and a half, the thermometer had risen ten degrees. The whole observations may be seen from the tables on pages 66, 67.

Time.	Milliamperes.	Temperature in Degrees Fahrenheit.
Before the current was applied		70
After 1 min. 30 sec.	900	80
,, 3 ,,	950	90
,, 4 ,, 30 ,,	1000	100
,, 6 ,, 30 ,,	1050	110
,, 8 ,, 30 ,,	1100	120
,, 9 ,, 30 ,,	1100	125
,, 10 ,, 30 ,,	1100	130
,, 11 ,,	Current stopped for observation. Potato very warm.	
,, 11 ,, 45 ,,	1100	135
,, 12 ,, 45 ,,	1100	140
	Odour of potato cooking became noticeable.	
,, 13 ,, 45 ,,	1150	145
,, 14 ,, 45 ,,	1150	150
,, 16 ,,	1150	155
,, 17 ,, 5 ,,	1150	160
,, 18 ,, 20 ,,	1200	165
	Removed milliampere meter, as it was calibrated to 1200 only.	
,, 19 ,, 30 ,,	Amperage above 1200	170
,, 20 ,, 30 ,,		175
,, 21 ,, 30 ,,		180
,, 22 ,, 50 ,,		185
,, 24 ,, 10 ,,		190
,, 25 ,, 30 ,,		195
	Potato began to steam, through faulty contact of electrode.	
,, 26 ,, 55 ,,		200
,, 28 ,, 25 ,,		205
,, 30 ,, 25 ,,		210
,, 31 ,, 10 ,,		212
,, 32 ,, 10 ,,		215

Total time of experiment, 32 minutes and 10 seconds. Spark-gap, 2$\frac{3}{4}$ inches, with 2-inch balls. Current generated by a Baker 12–24 machine run at about 1500 R.P.M.

Experiment with Steak:—

TIME.	MILLIAMPERES.	TEMPERATURE IN DEGREES FAHRENHEIT.	
Before the current was applied		56·5	
After 1 min. 20 sec.	880	60	
,, 2 ,, 20 ,,	900	65	
,, 3 ,, 25 ,,	940	70	
,, 4 ,, 25 ,,	970	75	
,, 5 ,, 30 ,,	1000	80	
,, 6 ,, 35 ,,	1020	85	
,, 7 ,, 45 ,,	1030	90	
,, 8 ,, 55 ,,	1040	95	
,, 10 ,, 15 ,,	1050	100	
,, 11 ,, 30 ,,	1080	105	
,, 13 ,,	1110	110	
,, 14 ,,	1150	115	
,, 15 ,, 20 ,,	1170	120	
,, 16 ,, 40 ,,	1180	125	
,, 18 ,,	1200	130	Note A.
,, 20 ,, 40 ,,	1200	135	
,, 22 ,, 10 ,,	1200	140	
,, 23 ,, 40 ,,	1200	145	
,, 25 ,, 10 ,,	1200	155	Note B.
,, 28 ,, 10 ,,		165	
,, 29 ,, 50 ,,		170	
,, 31 ,, 5 ,,		175	
,, 32 ,, 30 ,,		180	
,, 33 ,, 40 ,,		185	
,, 35 ,, 15 ,,		190	
,, 36 ,, 25 ,,		195	
,, 37 ,, 40 ,,		200	
,, 39 ,,		205	
,, 40 ,, 40 ,,		210	Note C.
,, 41 ,, 40 ,,		212	
,, 45 ,,		214	
,, 47 ,,		215	

Note A.—At 130 degrees it was noted that the juice began to flow from the incision for the thermometer.

Note B.—Irregularities of time and temperature readings due to the removal of the milliampere meter from the circuit (range 1200).

Note C.—Juice was noted flowing freely from the four surfaces not covered by the electrodes.

At the completion of the test the surface of the meat had a reddish appearance; however, investigation proved that the inside was thoroughly cooked; it had the appearance of very much over-done meat. This test was made on a piece of fresh beef about 1¾ inches by 1¾ inches by 4 inches. These experiments, which can be easily duplicated, conclusively prove the heat generated by electro-thermic penetration.

Another method in which this current can be generated is by means of Von Lepell's generator. It is composed of two massive electrodes of copper (Fig. 27, C) separated one from the other by a short space in which are placed three or four discs of thin letter-paper. In the spark-gap thus formed undamped oscillations are generated at the rate of 1,000,000 per second. These sparks are produced at about 3000 volts by the discharge of the step-up transformer B, worked from the ordinary alternating main. The oscillations thus set up charge the condensers E, E, and these in turn produce oscillations in the inductive circuit with which the patient is connected. In order to get the maximum effect, that is to say, sufficient frequency of oscillations of uniform size, the capacity of the condenser and the self-induction coil F must be balanced one to the other. Also it is evident that the generator must be such as to produce discharges following each other with extreme rapidity. For this it is necessary that the copper discs C, C, between which the sparks pass should be kept cool, hence they must be fairly massive.

The oscillations produced in the condenser circuit are not employed directly, but are brought to an inductance F, which can be regulated by different tappings, K, K. A further coil H, intercalated in this circuit, enables the operator to regulate the current to a nicety by means of a sliding contact controlled by a pedal and pulley. By this arrangement the hands of the operator are left free to apply the electrodes to the patient's body.

But a later and more satisfactory method for the production of this current is where the Von Lepell generator is replaced by a spark-gap of the "Telefunken" or "Quenched" spark type, such as is generally employed for the smaller wireless stations. It may be thus described: A frame contains two pairs of electrodes with a silver disc in the centre. These are kept 0·2 mm. apart by means of mica rings. The maintenance of this distance is essential in order to keep up the output of the apparatus, a small resistance coil is connected in parallel with one pair of the copper electrodes, which reduces the discharge voltage and increases the rate of sparking, and thus permits of reliable working. In order to prevent the electrodes from becoming over-heated, large copper discs are fitted to the centre and the end of each pair, thus acting as radiators. Two strong glass plates insulate these electrodes from the case, which is placed over the whole of the spark-gap, since it must on no account be touched when working, owing to the high tension of the

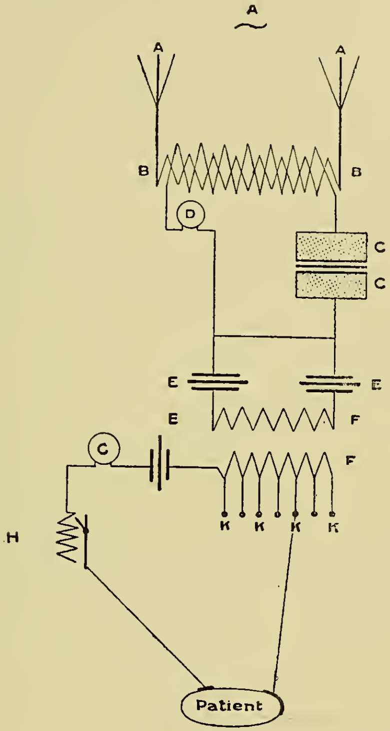

FIG. 27.

A. Current from alternating main, 100 or 200 volts.
B. Step-up transformer (about 3000 volts).
C. Two copper blocks with paper between, forming Lepell's generator.
D. Current meter.
E. Condensers.
F. Inductances.
G. Special hot-wire ammeter in electrode circuit.
H. Regulating Solenoid forming fine adjustment.
K. Different tappings on inductance forming coarse adjustment.

current at its terminals. This case is so fastened down that when removing it the primary circuit is broken so that the spark-gap can be handled with perfect safety.

The following diagram will give a clear idea of the whole of the internal working:—

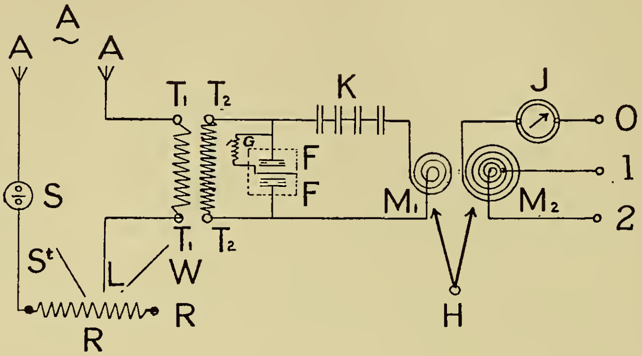

Fig. 28.

The current is flowing in from the alternating main, or from a generator giving an alternating current. It is turned on and off by the switch S, and passing through a resistance R, which is regulated by a lever L (S^t = strong, W = weak). It flows to the step-up transformer, T1—T2, where the voltage is converted from 200 volts to about 2000 volts, with an output of nearly two kilo-volt amperes. This causes the condenser K to become charged, and to discharge itself through the spark-gap F and its choking-coil G, which have already been described. The number of oscillations is about one million per second. The high frequency currents which are thus generated in the oscillating circuit are carried to a movable coupling coil M1, made up of several windings, where by means of the lever H this coil is brought near to a second, but fixed, coupling coil, M2, a current is generated in it varying in intensity with the distance between the two coils; the nearer they are together the greater the current, which is measured and indicated by means of a hot-wire meter, J. The arrangement of these coils is known as magnetic coupling. The fixed coil, M2, is subdivided, the connections being taken to the terminals 0, 1, and 2, which are connected to the patient; 0 and 2, where there is much resistance, such as the whole body, and the current flows from hand to hand; 0 and 1, where there is less resistance, as when we bind two small electrodes above and below the knee-joint. Current can be administered up to 2·5 amperes, though this strength is not usually employed. The Faradic sensation is avoided by means of the special spark-gap, and should it be felt, then it is an indication that the spark-gap is not properly performing its functions, and that it needs attention. Furthermore, on reference to the diagram it will be seen that there is no possibility of the patient being connected directly to the spark-gap. For the secondary current in what may be termed the "coil circuit" is only induced from the current in the spark circuit.

It is as well before trying this current on patients for each operator to see for himself its effect upon a dish of albumen or on a piece of meat; the lines of force are clearly shown, and an idea is gained as to the way the current acts.

The current may be employed in two ways, although one method is simply using it in a more intense manner than the other. These have been termed (1) medical or therapeutic diathermy, where the current is intended to produce only a slight increase in temperature without destructive effect; and (2) surgical diathermy, where the current is modified in so intense and concentrated a form as to produce destruction of tissue.

It will be noted that the coupling lever and the primary handle should be moved simultaneously. It is not sufficient to adjust the coupling to its full amount, and to leave the sliding resistance (primary handle) fully in; this gives too small a spark rate; it is necessary to increase the primary current as well, by cutting out the resistance which is effected by pushing the primary handle from right to left, for the fixed primary resistance is calibrated with the resistance of the sliding coil (magnetic coupling), and while moving this handle from right to left, the coupling lever is moved from left to right, thereby approximating the coupling coil.

It is very important that the electrodes should be applied evenly and with uniform pressure, otherwise the density of the current and consequently the amount of heat developed will vary, resulting in discomfort and damage to the patient.

Any metal may be used, such as lead, nickel, brass, but in order to secure that close contact which is so essential, wet cotton wool, lint or chamois leather may be interposed between the metal and the skin. Some of the electrodes for use with this current are here shown.

A very useful form of electrode is in the form of a nickel wire gauze, into which is sewn several thicknesses of flannel; these are made in pairs, 6 cm. square; 16 cm. square, and measuring 6 cm. × 10 cm. Whatever the electrode may be, it should be either held firmly against the skin or bandaged. I have found rubber bandage most useful for this purpose.

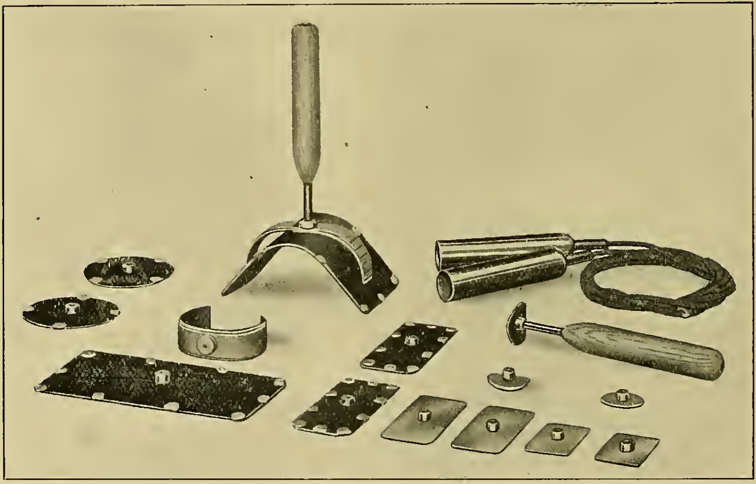

FIG. 29.

It is impossible at present to lay down any definite current strength for surgical purposes. Practical experience is essential. The technique of the surgical procedure is to place a large indifferent electrode somewhere on the patient's body, and then place a small specially constructed electrode on the part to be destroyed, which, as soon as the current is turned on, will take on an appearance something like that of a chamois leather. The current is then immediately turned off, the active electrode removed and reapplied to another spot in the growth. When the dead and desiccated area is complete, it may be removed by a sharp curette or allowed to atrophy or slough.

But the chief use of electro-thermic penetration is at present in its less or non-destructive form. Here it may be used in general arterio-sclerosis, in nervous excitement and insomnia, in certain forms of pain, notably neuralgia and migraine, neuritis, rheumatism and gout, and in certain joint affections, such as gonorrhœal rheumatism, and in post-operative stiffness.

In treating an infected or painful joint an electrode is bound tightly on either side of it, and the patient will invariably comment upon the grateful sense of comforting warmth which is induced.

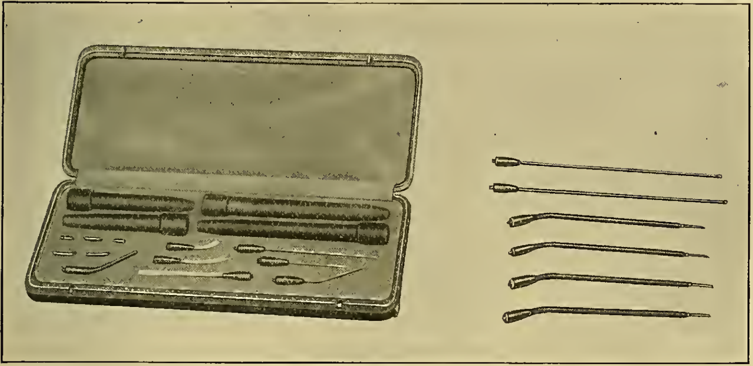

Fig. 30.

This current strongly stimulates all gland secretions, and is useful in hepatic troubles. It is also said to be good in nephritis, and under its influence the amount of albumen to diminish. Benefit is obtained in these conditions on account of the effects of the hyperæmia produced. Hyperæmia is due to the response of the vaso-motor mechanism in the natural effort to overcome the extremes of heat within the tissues. The hyperæmia thus produced induces the three following effects:—

(i) increases local metabolism,
(ii) improves local nutrition, and
(iii) causes the presence of a greater number of phago-

cytes. Hence it will be seen that the essential object of non-destructive electro-thermic penetration is the production of local hyperæmia, and hence it may be used advisedly in tubercular and other local infections as well as in cases of sluggish metabolism.

This apparatus, in addition to its capacity for giving thermic effects, is of use in conjunction with accessory devices made for the purpose; coupled up with a Tesla transformer, it is known as the "Oscillothermex," and it utilizes electrical oscillations for the illumination of X-ray tubes, giving an output which will give the B tint of Sabouraud in ten minutes.

In connecting the X-ray tube one cord is attached to the secondary coil of the Tesla and the cathode, and the other end of the coil is earthed, the anode and the anti-cathode being free and unconnected; hence there is no inverse radiation, we get a very steady illumination, and it is obtained in a simple uncomplicated manner. If high frequency electrodes be substituted for the X-ray tube, they can be used in the ordinary manner, and thus we can get auto-conduction with a solenoid, auto-condensation with a couch, the effleuve from a multiple point electrode, and so forth.

Professor Nagelschmidt has made much use of this current, and further accounts of it may be found in articles written by him.[1]

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[1] 1. "Über Diathermie," *Münschener mediz Wochenschrift*, 1909, No. 50.
2. "The Thermic Effect Produced by High-Frequency Currents," *Archives of the Roentgen Ray*, 1910, No. 120.
3. "The Method of Diathermy in Surgery," *Archives of the Roentgen Ray*, 1910, No. 122.
4. "Diathermic Treatments," *Archives of the Roentgen Ray*, 1910, No. 125.
5. "Behandlung des Lupus," *Zeitschrift für arztl. Fortbildung*, 1910, No. 23-24.
6. "Klinische Bedeutung des Diathermie," *Deutsche med. Wochenschrift*, 1911, No. 1.
7. *Archives of the Roentgen Ray*, 1912, No. 139.

CHAPTER XII

AN ELECTRICAL THEORY OF PAIN

"JOY is the source of all our pain," so said Ovid many years ago, and in all writings since his time to the present that I have seen I have not come across any adequate attempt to define an origin common to all pain, neither have I met any satisfactory definition of pain. Therefore in this section I venture to put forth a definition of pain and to find an origin common to all varieties, and to ascertain in some manner the nature of pain. Of course, until we have instruments of greater precision, microscopes of greater magnifying power, meters capable of measuring finer differences than we have at present, deduction alone is left to us to co-ordinate certain facts; and the only way to arrive at a knowledge as to the nature of pain is to try and seek that path along which the cause itself has travelled to produce the pain, and also to try and find out in what manner the means and measures used to relieve the pain effect their object.

One thing stands out pre-eminent, if not alone, as a producer of pain, and that is pressure; I doubt if we would be going too far were we to declare that *pain is pressure.* In most cases if we relieve the pressure we relieve the pain; and in those cases, if there be any, in which we have removed the pressure and yet the pain remains, I think that there, although we may have removed the pressure, we have not removed the effects produced by the pressure; a matter into which I will go more deeply later.

We all know that some pressure will cause some pain, *e.g.* the pain from abscess, from ingrowing toe-nail, from cancer, from congestive headache. This is so self-evident that it is waste of time to dilate upon it. But we will now endeavour to find whether all pain can be traced to some kind of pressure. It might seem difficult at first sight to connect the familiar liver pain in the shoulder, or the pain of the knee-joint in hysteria with pressure, but the connection, I think, is so clearly expressed in John Hilton's Lectures that from them I propose to find the explanation.

He states that sympathetic pain between the shoulder or over the inferior angles of the scapulæ is one of the most frequent—and shows that it must be connected with the distribution of some of the spinal nerves, because no other structures could express the pain. No other nerves occupy that position, except the 4th, 5th, and 6th dorsal nerves, which are distributed over the inferior angles of the scapulæ and interscapular space. Hence we must conclude that these nerves are the immediate seat of pain. If we trace internally the great splanchnic nerve from within the thorax downwards, we find it connected at its terminal end with the solar plexus, whence we may trace its distribution to the stomach, duodenum, liver, and pancreas. If we follow the other and upper end of the same great splanchnic upwards to the 4th, 5th, and 6th, which give peripheral sensitive filaments, over the angles of the scapulæ to the interscapular spaces and the adjoining skin, one can well imagine that these nerves carrying the influence upwards and backwards may explain the occurrence of the pain sometimes experienced in those external parts associated with the abdominal and visceral disturbances, *i.e.* pressure.

In brief, we have the great splanchnic nerve communicating with the solar plexus, and thence to liver and other organs of digestion on the one hand; and on the other, distributing branches to 4th, 5th, and 6th dorsal.

If pain is felt on the surface of the body it must be expressed by the nerve which resides there — no other structure can express pain. Therefore somewhere along the course of that nerve — if we carefully trace it back — we shall surely find the cause of the pain, *i.e.* the pressure.

Hence also in spinal disease pain is often mentioned —not in the spine, the seat of the disease, but at the cutaneous extremity of nerves issuing from the part of the spine actually diseased. The commonest form of this is in the hip-joint disease, where the pain is usually within the knee or on the inner side of that joint, and we know that it is caused by inflammation or pressure of the ligamentum teres, and that the obdurator nerve sends a branch to it as well as to the interior of the knee-joint and to its inner side.

Explanation of hysterical pain in hip and knee-joint in brief is that the sacral ganglia and lower lumbar ganglia of the sympathetic are connected with the great sciatic and partly with the obturator. These same ganglia are likewise connected with the nerves proceeding through the broad ligament to the uterus and ovaries. See diagram (Fig. 31).

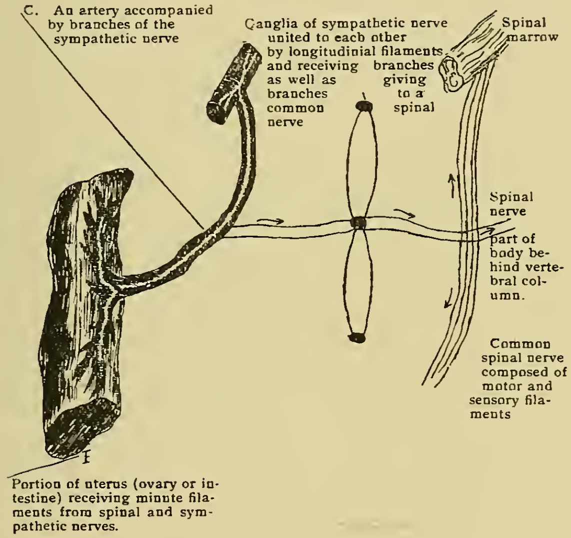
C. An artery accompanied by branches of the sympathetic nerve
Ganglia of sympathetic nerve united to each other by longitudinial filaments and receiving branches as well as branches giving to a common spinal nerve
Spinal marrow
Spinal nerve
Part of body behind vertebral column.
Common spinal nerve composed of motor and sensory filaments
I
Portion of uterus (ovary or intestine) receiving minute filaments from spinal and sympathetic nerves.

FIG. 31.

Diagram showing the Manner in which Reflex Pain is Caused.

The arrows indicate the directions which any pressure in uterus (ovary or intestine) might take, *i.e.* backwards towards the posterior part of body behind the vertebral column, or up into the marrow and thence down in the common spinal nerve to its muscular, articular, or cutaneous distribution. Hence the common backache of menstruation—of ovarian and uterine trouble—and the explanation of hip and knee pains in hysteria.

Two cases reported by Hilton of exostoses on the first rib pressing on the ulnar nerve caused pain and gangrene of the 4th and 5th fingers.

There are many other pains, all of which may be traced to pressure if we study them sufficiently, headache, toothache, the pains associated with malaria. This perhaps deserves a special word of explanation. We know that mild stimulation causes a cell to swell, and I suggest the malarial poison acts as this stimulant, and with the swelling up of a multitude of cells we get pressure and resultant pain.

Nature herself always endeavours to prevent nerves being subject to undue pressure—for as a rule they enter muscles where they would be most secure from pressure.

So much for pressure as a primary cause of pain, and under the term pressure I would include stasis or congestion.

I have already shown that peripheral pain is frequently the result of some central pressure or stasis, for where pressure is exerted, stasis more or less complete must be induced. Therefore while we can hardly call pressure and stasis interchangeable terms, yet as factors in the causation of pain they may be used as such.

The next step in this theory of the causation of pain is that the pressure causes an altered vibration of the nerves. It is known that our nerves are in a state of vibration. It is evident that pressure will alter normal vibration and may cause a readjustment of the elements. The probability is that almost every nerve and perhaps different parts of each nerve vibrate at varying rates, inasmuch as they vary in length, weight, and tension, and the law of vibration of strings may be held to apply to nerves.

All our physical sensibilities are due to an altering of our normal vibration (touch, pressure as in walking) or to different rates of vibration from without (*e.g.* sound, heat, and light).

Sound means a vibration of less than 36,000 per second, 18,000,000 vibrations per second mean heat, 462,000,000,000 produce a sensation of light, and with the increase of vibrations colour after colour is recognized, until with vibrations of 733,000,000,000 violet appears; vibrations of a higher rate than this we cannot appreciate; the X-rays we know exist, but we cannot describe them in terms of sensation. Of even greater intensity and higher frequency are the etheric vibrations given off by radium and radio-active substances; and these are classified with regard to their rate of vibration. It is not difficult to imagine an animal more highly specialized than we are to have double the number of senses with which we are endowed—say, a man from Mars, who might come to visit us, who would be quite able to transfer his thought from place to place, to have a sense of intuition absolutely accurate, *i.e.* being capable of noticing more rapid vibrations than we ourselves can.

The word vibration means "a recurrent change of position." Gage says, "When a vibratile body is compelled to surrender its own vibration period and to vibrate in an arbitrary manner imposed on it by another, the phenomenon is known as forced vibrations." There is always a tendency in Nature to return to the normal from the abnormal, as also a tendency to continue in the abnormal; for instance, in riding a horse, the animal may get into an uncomfortable trot, and if not checked has a tendency to keep in that trot, whereas if the rider put the horse into a new step altogether, say a canter, then on returning to the trot the tendency will be to return to the normal trot to which he has always been accustomed rather than to the abnormal trot which he has just taken up—so a nerve may get into a state of abnormal vibration, through pressure, let us say. If we can by massage, electricity, or vibration impose on that nerve forced vibrations, the tendency will be for that nerve, when the period of forced vibrations be ended, to return to its own normal vibration rather than the abnormal and painful vibration. I have, perhaps, strayed from the strict path of the investigation while on the subject of vibrations, but enough could be gathered by analogy to show that vibrations of our nerves exist, and, as I said before, it is evident the pressure would influence these vibrations.

I now wish to point out and trace the similarity between our nerve force and electricity. Ever since Galvani, nearly

150 years ago, separated the sciatic nerve from its lumbar attachment, and by means of a glass rod applied the cut end of the nerve to the exposed gastrocnemius of the frog, and found that the muscle contracted, animal electricity has been an accepted fact. It is needless to discuss the analogy between the electric phenomena produced by electric fishes and the currents produced by the human tissues, for it is admitted now that all tissues of living organism are capable of producing electric currents, and in confirmation of this a multitude of books have been written and experiments made from the end of the eighteenth century down to the present time. Whether or not there exist the two currents, the one of rest and the other of nutrition, or only one, it is not necessary for the purposes of this chapter to consider. One analogy, perhaps, should be mentioned, and that is, that when the nerve supplying the muscle be cut, that muscle no longer contracts. But when an electrical stimulus is applied the muscle does contract, the nerve and the electric current both giving the same result. Again Helmholtz has shown that "electric and nervous currents obey the same law."[1]

If the constant current be applied to the cheek, we get a sensation of taste; if we apply it (the same current) to the forehead, the sensation of light is produced; if to the ears, sound is heard.

The connection between nerve force and electricity is well set forth in the *Journal of the American Medical Association*, March 7, 1903: "I picture the nervous system and its mechanism in living action before my mind; I see beside it the central telegraph system of New York or London, with its radii of lines and cables, telephonic and telegraphic, its multiple switches, batteries, relays, transformers, condensers, shunts, duplex and automatic circuits, all this mechanism, like the nervous system, transmitting force and transmitting intelligence from point to point by terminal instruments, which move, talk, print light, inhibit, accelerate and regulate, and in one hundred ways doing what is done in the nervous system, and always by means of the same force—the only force capable of such vast and varied service."

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[1] Humbolt, 1799, 1827, Nobilli, Matteucci, *The Phenomena of Electro-Physiology*, 1844; Dubois-Raymond, *The Electro-Physiology of Motor Nerves and Muscles;* also Eckhard, Pflüger, Baiellacher, Erdman, Erb, Beard, and Rockwell.

Abrams' artificial electric stimulation of nerve fibres corresponds most nearly to their natural excitation, and we therefore assume in our present state of knowledge that nerve force and electricity are comparable.

If this be granted, and our nerves (be it nerves, their atomic elements, their ions, or what not) be in a continual state of vibration, then may it not be that the vibration rate being altered, their electrical conductivity, or resistance, is likewise altered, causing the electricity to flow in a different manner, and that this altered resistance is manifest to us as pain, and that pain is altered electrical resistance? But before formulating this theory let us look at the way in which the agents act which relieve pain.

Whether we take away the pain with opium and its derivatives, the coal-tar analgesics, electricity, massage, heat, light, counter-irritation or operation, there is one effect common to almost all, namely, the relief of pressure. The one thing common to all pain-relieving agents is the withdrawal of pressure from the affected part; the next thing that they do, either directly or indirectly, is to induce a different vibration in the offending nerve, either directly as by electricity or vibration, or indirectly as by drugs or counter-irritation. By withdrawing the pressure a different rate of vibration would be set up, for it is impossible to imagine anything which was vibrating under pressure at one rate of vibration, to go on vibrating at the same rate when the pressure is removed. And with the normal rate of vibration re-established, the normal electrical resistance returns and the pain is no more manifest.

To see that these agents do act in this manner and primarily relieve pressure, let us take them up individually. If we begin with morphia we are met with the clear statement of the leading authorities that the cause of the action of morphia on the central nervous system is very imperfectly understood. We know that morphia dilates the cutaneous vessels, and it is evident that this in itself would tend to relieve congestion, *i.e.* pressure, and this might account for some cases in which pain is relieved; but I am inclined to think that in the majority of cases it acts through the centres, and I suggest that it is on account of its depressant action on the nerve centres that it relieves pain. By its depressant action on all nerve centres it modifies vibration in the nerves, relieves pressure, and thus restores normal electrical resistance; and if morphia and other analgesics may give relief from pain by modifying the vibrations in the nerves, it may be that one can acquire the power to control voluntarily these vibrations, so that if the nerves are in a state of abnormal vibration which is evidenced as pain, the person who has acquired such power suffers no pain. This hypothesis would account for the apparent cures of so-called Christian Science, the actions of the fire-walkers of Samoa, and those of the Indian fakirs who will suspend themselves on hooks driven through their backs (acquired control over atomic vibrations), or sit upon a seat of upturned nails.

On this hypothesis, the relief of pressure is the relief of pain; and we can easily understand why counter-irritants, such as mustard plasters, blistering, &c., relieve pain. Why, too, electric-light baths, which cause the capillaries to fill (and these capillaries, it is computed, can contain two-thirds of the total blood in the body) and the deeper vessels for the time to be so depleted by thus withdrawing blood from the upper parts where the congestion (or pressure) is giving rise to the pain, should thereby relieve that pain.

It is interesting here to inquire—how do the X-rays relieve pain? By relieving pressure; and among the various hypotheses which have been advanced as to the manner in which this potent remedy acts are:

1. The neurones are stimulated, this resulting in lessening metabolism and diminishing blood supply owing to contraction of the cells comprising the arterial wall.
2. The muscular fibres themselves are stimulated to contraction. This would certainly account for most of the results of the X-rays, but it is difficult to explain why these rays should select either the neurones of the motor system or muscular fibres.

3. More probable it is that the cell protoplasm is stimulated to contraction, which suspends activity in degrees varying with the amount of radiation; but the point I wish to make is that to whichever hypothesis we pin our faith, the one point common to all these is contraction, and with contraction comes relief of pressure, and hence relief from pain. I have seen a large facial epithelioma come into the room, the patient's eyes full of tears with the pain with which the non-diseased part of her face was contracted. After a few minutes' exposure to the X-rays the muscles relaxed, and at the end of the exposure the patient was free from pain. What had happened? Superficially we could see that the surface, instead of being moist and discharging, was dry and glazed as though painted with collodion, *i.e.* the cell protoplasm had contracted, relieved the pressure and, *pari passu*, relieved the pain.

The explanation of the means by which static electrical currents in their well-nigh miraculous way relieve pain is similar. As Dr. Snow says, "Nothing so thoroughly overcomes the area of congestion as the static high potential modalities."

We can in some instances, by applying electricity to the surface where the pain is seated, relieve that pain, although caused by pressure in different parts along the course of the nerve, thus reaching by means of the centripetal neurone the suffering cortical centre or the point to which the pathological pressure is being applied. Having already shown that electric and nervous currents obey the same laws, we may conclude that electrical treatment, with its power of remedying stasis and restoring good conductibility, would seem to be the most reasonable treatment in cases where the nerve is suffering.

I think I have said enough to show that remedies which relieve pain relieve pressure, and though this is not logical and absolute proof that pressure is the principal cause of pain, I think that it is as near proof as our present state of knowledge will allow us to go. One point more, before I come to the concluding argument, should perhaps be made.

That is on the question why, having admitted or proved that the electrical resistance is altered in nerves, I should claim an altered sensation.

If, as we have shown, pressure causes a readjustment of the nerve elements, it is not difficult to understand that this readjustment should cause altered electric resistance, when we compare certain known substances with our nerves as conductors of electricity. We know that substances can be of the same chemical composition and yet have entirely distinct qualities (allotropism, *cf.* the familiar example of carbon and diamond). Similarly, if we use a copper wire for some length of time for the passage of electricity, it usually undergoes some change, some ionic modification, and becomes brittle; so, too, the filament in an incandescent lamp, after it has seen much service, though it is still a carbon filament in its comparative vacuum, has undergone some allotropic modification and does not burn so brightly and uses up a greater current. And so with our nerves, pressure causes a temporary allotropism—and pain may be defined as a temporary allotropism of the nerves caused by pressure—such allotropism causing an altered electrical resistance; and this brings us to the known law in electricity, "electrical currents travel differently in different resistances," and this difference we feel as pain.

As we have already seen, when pressure is exerted upon a nerve it does not follow that the patient refers the pain to the point of the application of the pressure. He may refer it to some point on the nerve far distant from the pressure point, as for instance the terminal endings of the nerve near or in a joint, or over the skin; and this, I think, accords with the theory I am endeavouring to set forth, and may be thus explained. There is no doubt but that the vibrations are primarily distributed at the point of pressure (and hence electrical conductivity altered), but take the case quoted of the exostosis of the first rib pressing on the ulnar nerve; here there were so many fibres at the point of pressure that the normal electric current can pass so freely as not to give rise to pain at that point. Not so, however, when the interference (and consequent alteration of vibration) reaches the finer filaments of the nerve; here the nerve has not bulk enough to allow the normal electric current to pass in its normal manner, and therefore manifests the altered resistance by pain. It may be that when a nerve is pressed upon, only some of its fibres or some of its molecular constituents have their vibration rate changed, and these not in a manner sufficiently strong to alter the normal vibration of their neighbours where they would carry the current in a normal way; but that when this nerve becomes attenuated and the fibres are few and thin, then there are less of any elements not altered in vibratory rate, and hence pain in the peripheral or terminal filaments.

Recapitulation or Summary

1. All pain can be traced to pressure, even as all pain-relieving agents tend to relieve pressure.
2. Our nerves are in a constant state of vibration, and pressure alters the normal rate of vibration.
3. Our nerves are conductors of electric currents.
4. With the altered vibration rate due to the pressure there is an altered electrical resistance.
5. In the altered electrical resistance the currents pass differently.
6. This difference is pain.

From which we may conclude that adequate pressure, by interfering with the normal vibrations of the nerve elements, causes altered electrical resistance in them. This is pain, or, to put it more briefly, pain is the subjective manifestation of altered electrical resistance in a nerve, primarily caused by pressure.

CHAPTER XIII

ELECTRICITY IN THE RELIEF OF PAIN

We know that pain is only a symptom and that scientific medicine demands the discovery and removal of the cause of this symptom; but the sufferer cares not for these scientific differences; he wants the pain removed, whether it be cause or consequence. But while we admit that pain is only a symptom, we must concede that it is a most constant and significant one, and calls for relief as for the removal of its cause, which it not unfrequently points out. In electricity we have an agent which not only affords instant relief in the majority of cases, but from its mode of action tends to remove the cause as well. If only as a substitute for opium and other analgesics, with their depressing after effects, the claims of electricity in the relief of pain have more than a right to be heard. But they rest on a surer basis than this. Electricity is not only palliative; it is curative, because it strikes at the result through the cause.

Electricity removes stasis, aids metabolism, and restores to the pathological painful structure the physiological function which is painless.

Even as there are different forms of pain, so are there many modes of electricity. We find the peripheral pain, usually due to local and visible causes; the pain of central origin (usually spinal), where the cause is invisible, but the subjective pain more diffuse; the true neuritis, or perineuritis, where the pain is either in the nerve itself or in its *nervi nervorum;* and lastly, the reflex pains which, though often difficult to trace, are very amenable to the properly chosen current.

The different modes of electricity from which we have to choose are the direct current, the induced current, the static modalities, the sinusoidal, magnetic currents, the various high-frequency currents, including electro-thermic penetration, phototherapy, and perhaps, too, the vibrator, since it is driven by an electric motor.

The secret of success lies in the choice of the appropriate modality. No one would walk into a drug-store, pick a bottle up at random, and take it with the expectation of a cure. Yet how many sufferers buy a battery and expect relief from electricity? and also how many men lightly administer electricity when they would not dream of prescribing a drug of whose therapeutic action they had an equal amount of knowledge?

Unfortunately, we have as yet no laws to guide us as to what modality is best suited to each condition. From time to time it has been suggested to frame a code of laws which should act as a guide, and probably the day is not far distant when such will be framed and laid down by some Electro-Therapeutic Association; the forerunners of this code may be seen in the Transactions of the American Electro-Therapeutic Association, 1909, 1910, and 1911.

In reading the various text-books, or receiving instructions from the various teachers, the student is struck by the variety of ideas held. In one city the static electricity is in general use; in another all talk is devoted to rheostats and the value of the constant current. In one clinique the 500 candle-power light is in general use, and the arc light neglected; in another the contrary conditions obtain.

The reason is, in my opinion, that a medical man is apt to abide by that agent which perhaps was first brought to his notice and with which he obtained his first result. And yet these, and all the others I have named, have their use in the relief of pain.

For some of the neuralgias, facial neuralgia for example, a mild constant current, with the positive pole to the painful area and the indifferent electrode anywhere on the back, will often succeed where most remedies fail.

In the pain of pelvic congestion the secondary induced current, administered by means of a bi-polar vaginal electrode for twenty minutes, the dose being a little less than the toleration of the patient, acts like an injection of morphine, the patient often falling asleep on the couch and going home free from pain.

Static electricity fills an important place as an agent in the relief of pain. In the pain of synovitis, neuritis, and many rheumatic conditions, the wave-current may be used to relieve the pain and remove the cause. In sprains, in rheumatic affections of the small joints, in pain from the swelling of fractures, the brush discharge invariably gives relief. In painful hæmorrhoids, or the dull aching which accompanies an enlarged prostate, the condition of the patient is immediately alleviated by means of static electricity with the appropriate currents and electrodes. In old-standing sciatica, well-directed sparks along the course of the nerve may make the patient jump, but the almost instantaneous relief from pain will cause him to smile with surprise and pleasure.

The 500 candle-power incandescent light has a truly remarkable action in the relief of pain. In either superficial or deep pain the light invariably relieves and, as a rule, from almost the first treatment. A patient came in recently with acute neuritis of the circumflex nerve; he was holding his arm as if it were broken when he came in, but after the first treatment he walked out with his hand thrust into his coat; three days later he reported himself as entirely free from pain. In a case of dysmenorrhœa in a very young girl, the light applied thrice weekly to the lower part of the abdomen has converted her period from seven or ten days of intense pain to a regular three or four days' painless period.

The uses of the X-ray are more familiar. Few things can be more striking than to see a patient with an inoperable cancer come up to the X-ray tube with eyes suffused with tears from the pain, in the course of five minutes smile with relief as the pain vanishes. In the neuralgia following herpes zoster, the X-ray is peculiarly useful. In 1908, a man aged 62 came to me with an intolerable pain along the course of an intercostal nerve. It was of four weeks' duration and had resisted all treatment. One year ago he had herpes lasting one week. Fifteen minutes' exposure to the X-ray took away every vestige of pain, much to the surprise of the patient. I must admit, however, that this is not an invariable sequence, for since then, though I have had almost similar successes, I have also had several cases in which a like happy result has not followed. The girdle and lightning pains of locomotor ataxia are often relieved by X-ray treatment as well as by the static-wave current to the spine. Myalgias can often be relieved and finally cured by three or four treatments with the vibrator.

The radiant-light bath, with 1000 candle-power, is useful when pain is general, as with the ill-defined rheumatic pains, toxic achings and pains, and muscular stiffness, which are all relieved by a ten minutes' treatment in the bath. A combination of two or more modalities is often of great service, especially in obstinate cases. In painful stiff-neck the vibratory treatment may well be preceded by the 500 candle-power light. The light may also precede with advantage the static treatment of sciatica. In the intolerable itching of eczema or that which accompanies hæmorrhoids, alternate treatments with the X-ray and high candle-power light give truly surprising results, and relief is experienced often at and from the first treatment. In fact, both as a curative agent and as adjuvant to other therapeutic measures, the high-power incandescent light is one of the most valuable agents in the relief of pain with which I am acquainted.

As to the way in which these various agents act, it must suffice at present to say that even if we regard the electrical application only as a counter-irritant, it is better than any chemical or organic one in the Pharmacopœia, as with it there need be no injury to the skin. Electricity acts according to the method employed and the nature of the pain treated. In referred pain we seek to alter the vibration rate of the nerve at the periphery, and the altered rate is transferred to the nerve centre, where removal of the pressure relieves the painful condition; whereas in a true neuritis we endeavour to remove the stasis, congestion, or pressure; that is, the condition upon which the pain is based.

The effect will often be the best guide in the choice of the most suitable current. Rarely, if ever, do I persist with any modality to which the patient evinces a decided objection. Even with the sparks from the static machine, the patient, although always recognizing their discomfort, will usually "ask for more," on account of the relief afforded, provided it is a case in which the remedy has been rightly selected. . . . So, too, it is with the high candle-power light.

Patients will complain, but they will return the next day on account of the marked relief which has been experienced.

Per contra, I have found that where the patient does not tolerate well the modality chosen, there is either a more suitable electrical remedy for this pain, or his condition has passed out of the reach of electricity and calls for surgical interference. It may be that the disease in a rheumatic joint has gone so far that the periosteum has become infected secondarily, or that a neglected stasis has broken down and pus has formed which must be let out, or it may be that in a long-neglected sciatica, where the pain is due to adhesions, nothing save operation and division of these adhesions will cure the patient. . . . But these cases, fortunately, are the exception and not the rule. The rule is that most forms of pain will yield promptly to the proper electro-therapeutic agent.

It is not suggested that the treatment of pain is the main object to be sought, albeit a consummation most devoutly to be wished. The formation of an early and accurate diagnosis is as important now as it ever was, and it always will be the only safe foundation for scientific treatment. What is clear, however, is that we should not allow the patient to suffer pain when the agent exists which will relieve it.

CHAPTER XIV

NEURASTHENIA, AND ITS TREATMENT BY ELECTRICITY

NEURASTHENIA, as its derivation denotes (*neuron*, nerve: *asthenes*, weak), means a condition of nerve exhaustion, or nervous debility.

Apart from the question of heredity, which undoubtedly is often a causative factor, neurasthenia owes its origin to prolonged overwork, or overstrain invariably associated with worry.

It may occur also from exhaustion following too much social gaiety, connected as this is with late hours and insufficient sleep. Sexual excess and undue alcoholic indulgence often play their part in producing this distressing disorder.

Neurasthenia is frequently found accompanying the toxæmia following such diseases as influenza, or that accompanying digestive troubles. Loss of relatives, or anything causing profound mental emotion, such as a railway accident, are less common but occasionally occurring causes.

The pathology of neurasthenia is at present undetermined, but I am inclined to think that, when discovered, it will probably be found to be a vasomotor disturbance reacting on the general nervous system.

The symptoms, I am afraid, cannot be dismissed so briefly. They are many and varied, the most common being a sense of pressure or heat at the top of the head, the patient often asking his medical adviser to put his hand on this place to feel the heat. Sometimes, in addition to the pressure on the top of the head, the patient complains that there is a sensation as though his head were opening and shutting. One will complain that there is a cracking in the head continually night and day, another that small explosions or shocks are continually taking place. There is usually a sense of depression and hopelessness as to the result of the treatment. Tears are not uncommon. The neurasthenic is always ready to describe his symptoms, and to describe them at some length, and with a wealth of detail, for they are very real to him. Insomnia is not uncommon. The patient often says that he hates to go to bed in the night, and equally hates to get up in the morning. The lack of power to concentrate is usually a marked symptom, the patient often being unable to read a chapter of a novel or a column of the newspaper, and he cannot focus his attention long enough to add up a row of figures. Unreasoning fears are often present—dislike to society, anthropophobia; fear of solitude, monophobia; fear of space, bridges, &c., agoraphobia; inability to sit quiet, calisphobia; fear of blushing, eruthrophobia; mysophobia, fear of dirt or contamination; nosophobia or pathophobia, the dread of sickness or disease; astrophobia, the fear of storms; or panophobia, the fear of everything.

Another characteristic peculiarity is difficulty in distinguishing trifles from essentials. Matters which appear small to the healthy mind seem to the neurasthenic to be of momentous import. These patients are, as a rule, very easily tired, and early exhaustion after trivial exercise is very often a marked feature.

Objectively, there is usually very little. Sometimes the tendon reflexes are increased and the muscles respond more readily to electric stimulation. It may be possible also to elicit a tender spot in the spine. I do not propose to differentiate here between the several varieties which have been described, such as cerebral, spinal, sexual, visceral neurasthenia, &c., for these are but local symptoms of a general involvement of the nervous system. The heart is sometimes slow and sometimes quick, there may be attacks of palpitation, and there may be visible exaggeration of the pulsation of the aorta and large vessels. A slight scratching of the skin may produce weals, and I have seen the phenomenon known as dermography, in which a word traced on the skin by the end of a penholder shows out in vivid redness. There may be flushings of the skin. The sphygmomanometer often reveals a startling alteration in the blood pressure, and it would seem to give us a means of dividing neurasthenics into two distinct classes, which need totally distinct forms of treatment. In some cases the maximum arterial tension is low, varying from 90 to 118 or 120 mm.; in others its height is equally abnormal, ranging from 160 to 180 and even 200 mm. It is this difference that I will dwell upon later in discussing treatment, for obviously treatment must be widely different in each class of case.

The urine may show a large quantity of phosphates or urates, and sometimes indican is present in excess, though this latter is probably more an indication of the cause than a symptom of the disease.

The diagnosis should not be difficult if the physician will listen carefully and patiently to the symptoms as narrated by the patient, however great a tax this may be upon his time.

Organic nervous disease can usually be excluded on a careful examination. Hysteria and hypochrondriasis may occur to the physician's mind at the first interview, but, as a rule, can be easily distinguished from true neurasthenia. Treatment gives a diagnostic point between these diseases and neurasthenia: the hysteric patient does not really want anything done; he will come, but he does not wish treatment, especially if it involves trouble or discomfort, whereas the true neurasthenic will allow anything to be done, no matter what the cost or the inconvenience. Graves' disease before the exophthalmos is present, and organic and functional heart disease should be borne in mind. Lastly, I have seen neurasthenia confounded with melancholia.

I am glad to say that the prospects of recovery in this disease, when treated by modern methods, are very good. Certain it is, that in traumatic cases, caused by railway or other accidents, when an action at law is pending, no treatment will clear up the symptoms except a verdict for the plaintiff with damages, when the cure seems to be complete within an hour, unless, perhaps, an appeal is pending. A guarded prognosis, however, should be given when the neurasthenia is hereditary without any exciting cause. Of course, the longer the disease has been in existence the slower will be the recovery, but even in cases of two or more years the chances of a cure are good, provided the physician and sufferer have patience with each other.

My own experience has been more favourable in cases which are accompanied by marked alteration in the arterial tension.

With regard to treatment, I find it impossible to rest satisfied with the accepted views. Most of our leading text-books insist that the most important treatment is rest; and complete rest with isolation, or failing this, a prolonged holiday trip. The rest cure is certainly a valuable method of treatment. It is useful in the milder forms of neurasthenia, and also used as a *dernier ressort* in the cases, though happily they are few, where both patient and doctor are striving intelligently together where electricity fails to effect a cure. A sea voyage is indicated, I think, when the patient is able and ready to enjoy it, after his distressing symptoms have been ameliorated. One point in the treatment of neurasthenics I give in the words of that cheerful philosopher Plantin, in his ode or prescription of happiness, and it is of the utmost importance in the successful treatment of neurasthenia. It is, "And not too much to do with one's relations."

The treatment which has been most successful in my hands is that by one or other of the various forms of electricity. The form of electricity must vary with each class of case, and it is the physician with a full armamentarium who can reasonably hope to secure a large percentage of success. In cases of sub-normal blood-pressure, the most successful method in my hands has been the application of the static brush discharge to the bare spine from a machine capable of giving at least half a milliampere at a pressure of 750,000 volts. The technique will be found fully described in the chapter on the static brush discharge.

I apply the current for twenty or thirty minutes daily until I get a marked amelioration of the symptoms, when I continue it three times a week until the patient ceases to complain; then I tell him that he may take a sea voyage or take a holiday, but I have often found that when this period is reached he is quite able to go on pursuing his usual avocation.

During the treatment I encourage him to go to business as usual, persuading him, however, to keep regular hours and avoid alcohol or over-fatigue. The patient being kept at his work, his mind has something to dwell upon other than his own symptoms, and I have found that nothing is worse for these patients than to give them time for introspection. Under the treatment, they find, day by day, that they can take more interest in their work, and that, however slightly, the power of concentration gradually returns, and the periods of content occur more and more frequently, replacing the continued depression.

In those cases where the maximum arterial tension is high, I employ the direct D'Arsonval current, sometimes with the patient lying on an auto-condensation couch connected to one pole and the other to a metal plate placed over the abdomen. I give them from 1000 to 2000 milliamperes from ten to fifteen minutes, the current being derived from a coil or from a high-speed static machine capable of giving 2 to 5 milliamperes at a million volts for ten to fifteen minutes. More recently, I have been using the electro-thermic penetration, with the patient holding a handle in each hand; the current often reading up to 750 milliamperes, and continued for twenty minutes. This avoids undressing, and has given me nearly as good results.

I try to listen to each complaint of the patient, and to treat it symptomatically.

In those cases where at first the insomnia does not readily give way to the treatment, I prescribe hot mustard foot-baths taken thus: Mix three-quarters of a tumblerful of unmade mustard into a cream with warm water, and stir this into a foot-bath full of hot water at a temperature of 95 to 100° F. Place this foot-bath in a big bath, with hot water of the same temperature, or slightly warmer (100 to 105° F.), continually running in. Let the patient keep his feet in this for half an hour; it is well to give him a book to read, so as to pass away the time more pleasantly. The hot mustard foot-bath may be alternated with a CO_2 body-bath, and they should be taken just before retiring. I have found compound tincture of passiflora a very valuable adjuvant to physical treatment, giving it in four-drachm doses in water as required;

that is to say, telling the patient to take a dose when he feels tearful or wakeful or unduly nervous, or, in short, when any particular symptom becomes unbearable. It is needless to say where constipation is present this must be treated, and in the first instance I usually rely upon cascara. In case of failing appetite, I give an ordinary mixture, such as:

℞.

Tr. Nuc. Vom.	mv.
Tr. Capsici	miij.
Sod. Bicarb.	gr. x.
Tr. Card. Co.	ʒi.
Inf. Gent. recent ad	ʒiv.
M. et mitte tal	℥viij.

Sig.:
ʒiv. ex. aq. t.i.d., a.c.

In some obstinate cases, where the spinal brush discharge has been applied for some time and a change seems advisable, I give the static-wave current applied to the spine with a large gap of 12–14 inches.

A new method for the treatment of neurasthenia is one with which I have had no practical experience, and so will deal but briefly with it.

It is that advocated by Dr. Vittoz, and consists in teaching the patient to control the vagaries of his thoughts by a simple series of exercises: Concentration of the mind on a figure, following out the curves of the mathematical symbol for infinity, ∞, while eliminating the mental pictures of the wrong objects from his mind after looking at them for a time.

Dr. Vittoz states that the results obtained have surpassed his hopes, and have well rewarded his labours.

But to return to the static treatment; with regard to the way in which it acts in relieving neurasthenics, I am well aware that several theories may be advanced. In some cases, more especially in the highly nervous subjects, I have found that the plain static bath gives excellent results, and inconsistent as it may seem, lowers a high blood pressure, or raises a low one, as may be needed. The only explanation of this that occurs to me is as follows.

We know that the blood-vessels are supplied with nerves for vaso-constriction and vaso-dilatation, and that in a pathological state of the arterial tension the nerves of one or other of these varieties is in an abnormal condition. It may be that the static current acts on the abnormal set of nerves, and if the vaso-constrictors be in a state of tension, this tension is relaxed, while if the vaso-dilators be at fault, they are likewise acted upon by the static current. Thus the arterial pressure is approximated to the normal in either case. Or the direct D'Arsonval current, producing as it does a lower blood pressure, and also the elimination of toxins, gives us a like happy result in neurasthenia associated with a high blood pressure. Dr. James Metcalfe, of Bradford, in an interesting paper on this subject (*British Medical Journal*, Feb. 18, 1911), quotes several cases of neurasthenia treated with D'Arsonvalization and static electricity, in which he says that in those neurasthenics in whom the symptoms pointed to a condition of pure neurosis he had observed that static electricity produced the best results. He also mentions the fact that most of the cases seen by the electro-therapeutic physician are the obstinate, obdurate ones which are not amenable to the usual remedies.

Dr. Benham Snow, in a kindly criticism of an address on this subject given in Philadelphia before the American Electro-Therapeutic Association, laid much emphasis upon a pelvic origin of neurasthenia, and said that 75 per cent. of his male cases suffered from some form of prostatic trouble, and that he relieved the neurasthenia by treating that gland, and that in female cases a pelvic condition was often the origin of the trouble, and no such case could be cured until the local mischief was treated.

It will be the opinion of all neurasthenics, and indeed does not admit of denial, that the above treatment is far from exhausting the subject, but the complexity of the symptoms and the difficulty of the varying cases make neurasthenia a well-nigh inexhaustible field.

CHAPTER XV

THE TREATMENT OF OBESITY

"Little do (sic) the faculty imagine the misery and bitterness of life through the parasite of corpulence or obesity." So wrote Mr. Banting in a letter on corpulence forty years ago. At the present date, however, this condition is being recognized as a disease, and one to be treated by the profession; not that this recognition is really a novelty, since it obtained in 1850 when Erastus wrote *de Pinguidine.*

That obesity is a disease, and a disease leading in some cases to serious and even fatal complications, is generally admitted. The derivation of the word is misleading: *obesus,* corpulent—from *ob* and *edo,* fully fed; for it by no means necessarily follows that the very corpulent person is either a large or injudicious eater; for while an excess of food may be a determining cause, it is a known fact that very thin people are large eaters, and also that many sufferers from obesity are small eaters. Generalization is impossible, and each case must be considered on its merits.

Obesity may be defined to be a state of disordered metabolism, accompanied by superfluous adipose deposits and various functional disturbances.

Of the causes which predispose to this disease heredity plays an important part, but it is interesting to note, in the light of the treatment about to be suggested, that other states of disordered nutrition, such as rheumatism and gout, are transmitted indifferently with obesity. Another predisposing cause is some disorder of the circulatory system, *e.g.* anæmia and chlorosis, since here the oxygenating power of the blood is deficient. Age undoubtedly plays some part, as also does sex. Women have a tendency to grow fat at the climacteric, though the disease is often manifest in quite young girls. Men at middle age, more especially if they at this time adopt more sedentary habits, are apt to increase in weight. The question of food has already been mentioned, and it must be admitted that eating and drinking to excess may bring about an obese condition, but Bouchard distinctly lays it down that less than half (40 per cent.) of fat people only are large eaters, and that one in every ten eats less than the usual quantity of food. The same authority, on the question of exercise, calculates that 37 per cent. of fat people only take too little exercise and that 28 per cent. take more exercise than the average person, but there is no doubt but that "deficient muscular activity, by diminishing the amount of oxidation of tissue, favours obesity, especially in cases of idleness following on a period of considerable energy, the quantity of food taken remaining the same; and since, as a rule, the stouter the person the less capable is he of exercise, these two conditions re-act one upon the other in favour of fat production." Thus Sir William Allchin, and I have quoted this paragraph as it clearly enunciates the principle upon which the electrical treatment of this disease is based.

There are other causes of obesity, such as fevers, hæmorrhage, cardiac disease, alcoholism; and it has been attributed to certain drugs: but whatever the cause, it must be looked upon pathologically as a case of deficient or delayed oxidation; that is to say, those parts of food elements which should be normally converted into CO_2 and water are stored up in the tissues as fat.

As a rule, in those cases which come to the physician for treatment the excess of fat is due to a diminished energy of nutrition of the cell functions, and it is this that must be stimulated. This is especially true when the obesity is associated with anæmia.

The morbid anatomy of obesity is well known. Certain situations seem to be usually selected by this disorder, such as abdomen, neck, buttocks and just below the shoulder-blades, and if this were all Sir William Allchin might not have laid it down that "obesity should, on the whole, be regarded as a grave matter." But the gravity of the disease lies in the fact that in the corpulent person the liver and heart are often enlarged and infiltrated with fat. The lungs are usually small, and blood changes may occur to such an extent as to be visible to the naked eye. Hence such symptoms arise as palpitation and dyspnœa, which may vary from a slight breathlessness to marked difficulty in breathing. The patient is easily exhausted. There may be a feeling of faintness on exertion or sensation of choking or of fullness in the chest. There is a tendency to avoid the use of the voluntary muscles, and it will often be seen on physical examination that their fibres suffer from fatty infiltration.

There is usually a feeble precordial impulse. The sounds are weak, and the first especially may sound muffled. The pulse is very variable; it is rarely quite normal, sometimes weak, often irregular or intermittent, occasionally very slow, the variation being due, of course, to the amount of mischief the fat has wrought in the heart structure.

The symptoms of this disease are well known, and scarcely call for any mention. Most of those occasioned by the heart condition have been suggested; in addition there may be headache and attacks of giddiness. The corpulent person is usually a cheery optimist, but there may be periods of peevishness and irritability. Varicose veins and hæmorrhoids occur as a direct result of the veins sharing in the generally disordered metabolism. Backache, due to the enlarged abdomen, is quite common. Gout is also common, since this is a disease caused by deficient oxidation, but all these symptoms are of small importance compared with the results of obesity upon intercurrent affections. Almost all acute diseases are unfavourably influenced by a corpulent condition, and for this reason, if for no other, should the physician do all in his power to relieve the condition of obesity.

It is for this reason that a reduction in weight is advisable for those who are otherwise apparently healthy individuals. It may seem difficult in some cases to decide whether or no to advise any reduction. Of course, in very advanced degrees of obesity, when the general impression created by the patient is marked, there is no doubt as to the decision as to whether or no to advise treatment. But there are certain border-line cases where there is only a small excess of fat, in which it were better to advise the patient to bear with it, and to refrain from any attempt at reducing it. These cases chiefly occur in women who have always been under weight and somewhere about the age of forty put on weight, where they least desire it. In these cases the increased fat is noticeable to them, but to the ordinary observer would pass unnoted, and their weight will be found to be about normal; and these are unfavourable subjects for the electrical method about to be described, not that it will do any harm, but that their weight is difficult or impossible to reduce.

Before describing the method of weight reduction by electricity, mention perhaps should be made of massage, Turkish and radiant heat baths, drugs and diet.

Massage has a great reputation for the cure of obesity, and probably this condition in certain cases is ameliorated. Here it is probable that the intestines are favourably influenced, and that their atonic condition being ameliorated, a generally improved state of health supervenes. But when one recalls the number of women who have been massaged for years, the long duration of the treatment alone speaks against its efficacy, although it is doubtless a useful adjuvant to other forms of treatment. It may be interesting in this connection to recall von Noorden's experiment, which I will quote: "I once attempted to determine the effect of local massage on local fat deposits, and ordered daily massage of one arm in a stout lady; massage was given according to all the rules of the art for a period of six weeks, a treatment every day. The result was that the arm that was massaged gained one and a half centimetres in circumference, while the other arm that was not massaged retained its old dimensions."

Turkish baths and light baths *per se* I consider well-nigh useless as weight-reducers. True it is one, two, or three pounds may be lost for a period of hours, but rarely for a longer period. Drugs, such as Thyroid, Iodine, Fucus vesiculosus, have their uses and their dangers, and should only be then taken under careful medical advice and supervision. The same advice applies to the reduction of weight by diet, and text-books on obesity and on general medicine contain full particulars of the methods of Banting, Ebstein, Salisbury, &c.

The electrical treatment of obesity is no novelty.

In July 1909, Professor Bergonié read a paper before the Academy of Sciences upon the employment of electricity, in order to provoke a general exercise—or stimulation—of the muscles of the body towards a general therapeutic end. In it he embodied the work of some nine or ten years. Since then I have had the opportunity of seeing M. Bergonié at work and receiving many courtesies at his hands, and studying and practising his methods, and it is his apparatus and his method that I am about to describe, and which has yielded such good results in my hands.

The axiom upon which the treatment is based may be thus stated:—

The proper use of any organ increases the vitality peculiar to such organ, and also influences the vitality of the entire organization.

This general law is demonstrated particularly in the case of the muscular system—on the one hand, active exercise strengthens the muscles concerned; and, on the other hand, combats the conditions in which combustion is insufficient, such as obesity, diabetes; or incomplete, as in the uric acid diathesis.

This electrically provoked exercise consists of the muscles being contracted by electric stimulation some hundred times a minute, the aim being exercise without fatigue—a desideratum which has long been sought, and will be admitted to be of the greatest therapeutic value.

Of the various currents which have been tried and found wanting for this purpose, such as the direct, the high frequency, the sinusoidal and Leduc's current, it is not profitable to enter into a discrimination now.

The current finally selected, and which is now giving the most satisfactory results, is derived from what may be termed an induction coil, or a coarse wire Faradic, whose co-efficient of transformation is two or three (*i.e.* four volts in the primary and eight or twelve in the secondary) (Fig. 32). Below the coil are the condensers. The current is rhythmically interrupted and reversed by means of a metronome about one hundred times a minute, the aim being to obtain muscular contractions of maximum strength, with a minimum of—one cannot say pain, for there is no pain with this treatment—sensation. To accomplish this aim we must have a perfect regularity of the waves, induced by the make and break of this current. They must be regular, equal, and synchronous. For as much as a muscle contraction is agreeable and painless if produced by such waves, it is equally disagreeable, and even unsupportable, if these waves are unequal in form or frequency. One of the most necessary conditions requisite to insure this regularity is that the interrupter must act in a perfectly even manner, and the old-fashioned simple ribbon interrupter, weighted at its extremity with a piece of iron, seems to give the greatest satisfaction. The length of this can be varied so as to produce a musical sound of as pure a tone as possible. A little experience soon teaches this. The tone is also modified by the amount of current allowed to flow through the coil. The binding posts should be solidly fixed with screw nuts into the board; also, the screw bearing the platinum point should not work too easily. When in working, there should be no spark visible, even if the room be darkened, and this is a condition most difficult to obtain, but indispensable in order to have painless energetic muscular contractions. A condenser of suitable capacity and its proper adjustment is one of primary importance. A condenser which one could vary would be an ideal adjunct to this apparatus. In practice the main commercial direct current is led through a resistance bank of lamps and through a circular wire

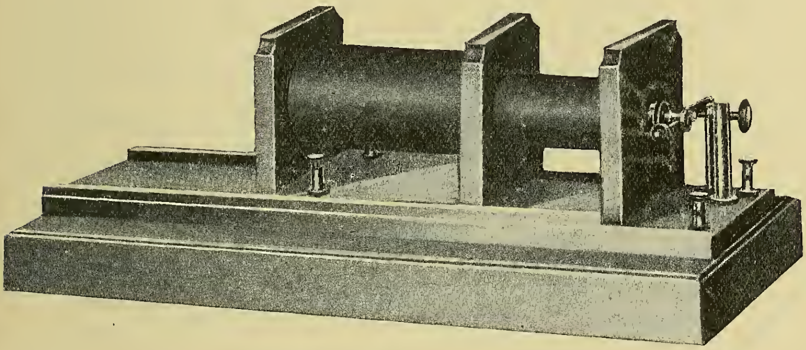

FIG. 32.

rheostat—a volt meter and an amperemeter are put in circuit, and the current led to the coil (Fig. 33). It is varied by means of the wire rheostat, until there is no sparking at the interrupter, and the requisite musical note is heard.

The quantity of current is quite considerable, an average reading being C. = 2·5 A., and E. = 24 V., the expenditure of energy in the primary being over 61 watts, which makes this apparatus—apart from its other modifications—something quite different from the Faradic coil of former times. So much for the primary current.

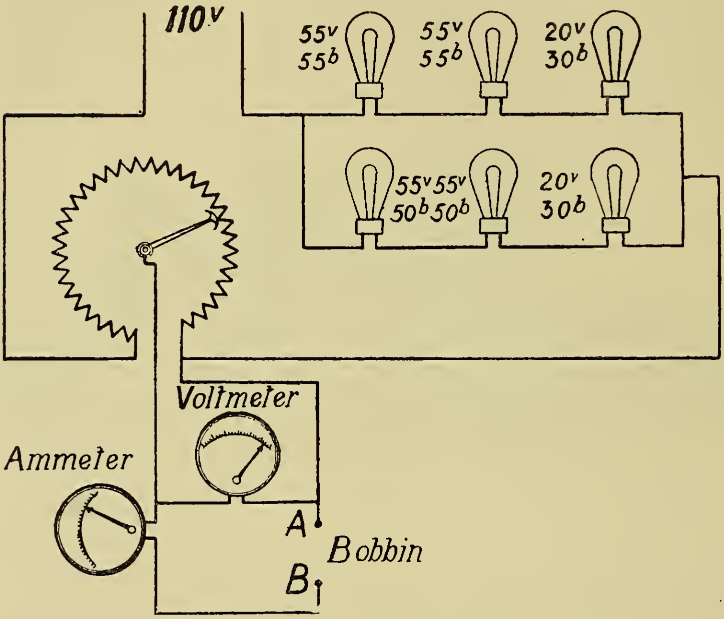

FIG. 33.

As this is intended to be a practical treatise, I do not propose to deal at any length with the study of the secondary current, but I wish to reproduce two oscillographic tracings—one showing the difference between the current and interrupter working harmoniously, and the other when the interrupter was not working regularly—and the patient is as aware of the difference as any one who sees these oscillograms.

The points to be noted are (*inter alia*) the purity and clearness of the curve, when there is no sparking at the contact point; but where the interruptions are irregular, the curve is irregular. Note also the size of curve; it is much smaller in the latter case, for the irregularity being clearly felt by the patient, it is necessary to sensibly diminish the amount of current employed, and, secondly, the energy of the contractions produced. The oscillations seen after the "break" in the primary depend upon the composition of the circuit, such factors being resistance, capacity, &c.

These oscillograms I publish (Fig. 34), thanks to the courtesy of M. Bergonié, who made them with the oscillographic apparatus of M. Blondel. They were published in the *Archives d'Electricité Médicale.*

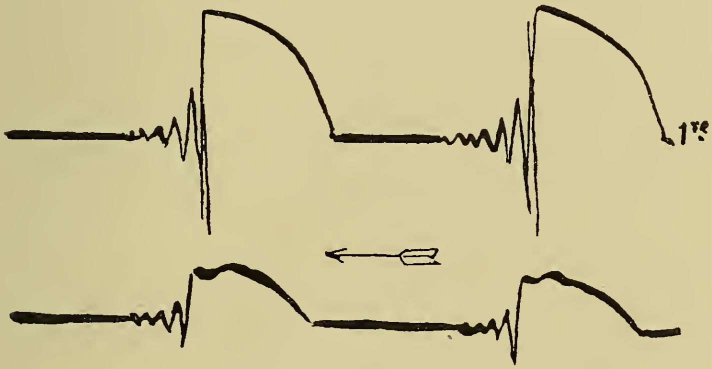

FIG. 34.

As to the rate at which the interrupter should work, the frequency which appears to be the most favourable is that of thirty times per second.

We have finished with the primary and secondary currents and come now to the metronome (Fig. 35), with which I have already said the current is interrupted on its way to the patient. It is not possible to tetanize a muscle by the Faradic current without giving rise to pain, fatigue, and even the exhaustion of the muscle. It is necessary, however, to follow each electrically executed contraction of the muscle with a period of rest equal in length; in a word, rhythmic currents must be applied. As a matter of fact (as an examination of the oscillograms shows, or watching the muscular contraction proves), we do not get a symmetrical current—*i.e.* the efficacy of the stimulation varies with the personal factor, viz. the patient. But by reversing the current at each interruption, we more nearly approximate regularity. The metronome is the most simple and practical apparatus for obtaining this rhythmic inversion. The wave rheostats, which allow of the progressive increase and the slow decrease of the current, are not suitable for this apparatus, however useful they are for other classes of disease, notably wasted muscles. But here we are dealing with healthy muscles, which need the most energetic work possible, and it is obvious that the muscle which is made to contract twice a second does more work and produces a more intense combustion than the

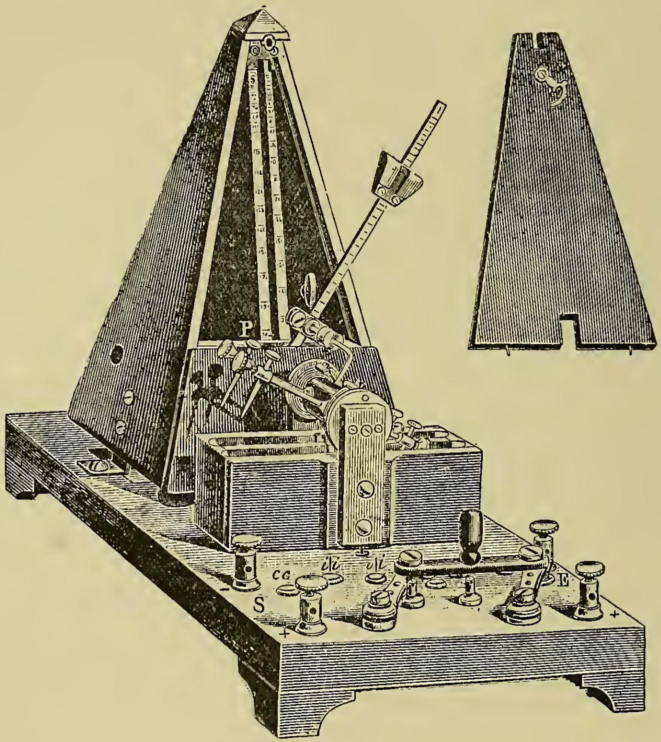

FIG. 35.

muscle which is only contracting once per second. But in practice the rate which produces the best results and which

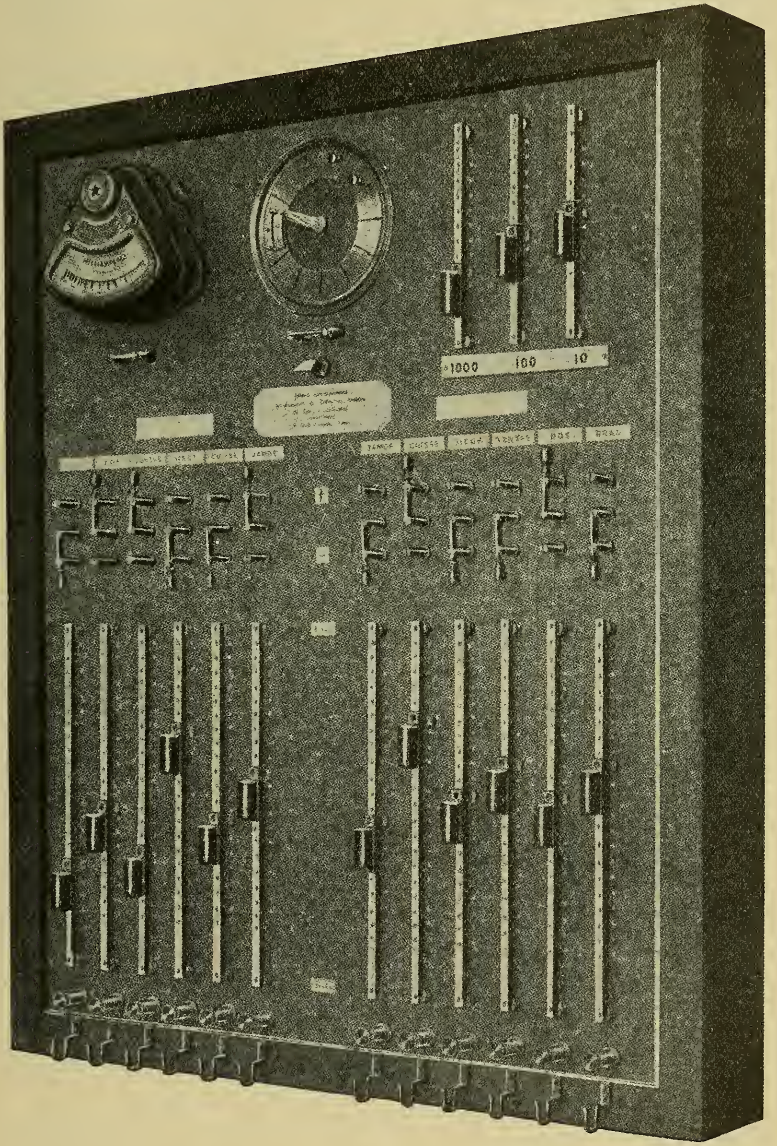

Fig. 36.

is the most comfortable to the patient is when the metronome is regulated to 100 to 120 interruptions per minute.

Having passed through the metronome, the current reaches a wall plate which at first sight looks rather complicated (Fig. 36). From this it is distributed to the various electrodes. In addition to the two points of entry for the current, it contains a hot wire meter graduated from zero to 100 ma., and an automatic clock by which the length of the treatment can be automatically fixed at the expiration of five, ten, fifteen, or any multiple of five minutes up to one hour. It also carries a rheostat with three rows of resistance —one row of 10,000 ohms, one of 1000 ohms, and one of 100 ohms—each row being divided into tenths. Below these are twelve knife switches, controlling the polarity of the twelve electrodes—being positive if the switch be up, negative if turned down; thus many varied combinations may be made. Below these again there are twelve rheostats, each corresponding to the part where the electrode is applied—back, leg, arm, abdomen, and so forth. These are simple sliding resistance, with twenty stops in each, each stop being equal to 100 ohms, so that each part of the body receives that amount of electricity which it can comfortably bear.

Lastly, on the lower edge of the wall plate or distributing board are the points of exit for each electrode.

Electrodes.—As the object aimed at is the simultaneous stimulation of the greatest number of muscles of the body possible, the electrodes should be of as large surface as possible. They are of two kinds—stationary and movable. The stationary electrodes are always the same, irrespective of the size and weight of the patient, and take the form of a semi-reclining chair, of which they constitute the seat and back, two forming the seat and two the back, being separated each from the other by a small space (Fig. 37). They are made of metal, and connected to the points of exit on the wall plate. Each electrode is covered with a towel wrung out of warm water, and the patient, clothed only in a light dressing-gown, seats himself on the chair. The movable electrodes are semi-cylindrical pieces of metal, varying in surface, form, curve, &c., and are placed with the intervening warm, wet towel on the part of the thigh, under the calf (resting on a special support), on the abdomen and on the arms—twelve electrodes in all. The total surface covered by these electrodes is very large, and may, in some very fat people, be even 10,000 square centimetres, which would work out, with a 50-ma. current, at 0 ma. ·01 per square centimetre. This, one can easily see, would only produce a comfortable feeling at the point of contact, and that pain is impossible. The resistance which the body offers naturally varies considerably, but Professor Bergonié has measured it, with all the electrodes well applied and well dampened, at less than 200 ohms.

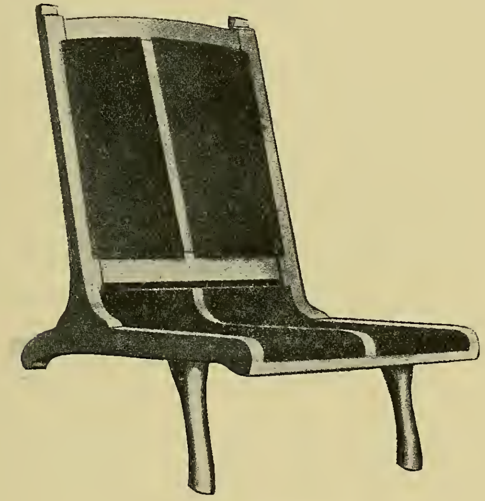

FIG. 37.

The movable electrodes may be held in position in two ways—either by means of rubber bracelets, or by sacks of sand placed on the lower limbs and abdomen of the patient, exercising a considerable pressure. This pressure is of considerable advantage. Firstly, it keeps the electrodes in good contact, in spite of muscular contraction; and, secondly, it gives more work to the muscles when they contract. Some fat people can be thus laden with the sacks up to 200 pounds, without an appreciable diminution in the electrically stimu lated movements. This great weight is easily moved by the contracting muscles without fatigue and without the least painful sensation. Were it not for the passage of the electric current, the weight would be difficult to support.

For average current, with the electrodes arranged one pole to the back, and the other pole to all the other electrodes, the metronome working, the interrupter well regulated, to produce good contractions with a man of ordinary muscles, I find 25 to 30 ma. sufficient, but I have seen in very fat women with muscles poorly developed, 70 to 80 ma. registered on the meter, without the sensation being in any way painful.

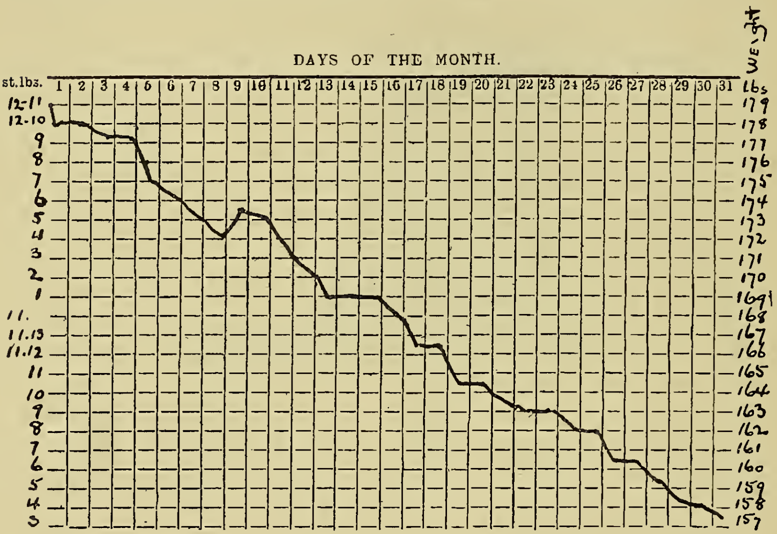

Fig. 38.

The treatment should never be tiring, but if at first it be too violent or of too long duration, there will be some muscular stiffness. As a rule, it is best to begin with a treatment of twenty minutes, increasing by five minutes daily, until forty or forty-five minutes daily is reached. Professor Bergonié in some cases advocates increasing this to sixty minutes and giving the treatment twice daily, and says that even this is not a maximum, but naïvely adds: "It is about enough for most patients."

It is, I hope, superfluous to point out that patients undergoing this treatment should be under continual medical supervision. In a patient in whom great metabolic changes are daily taking place, it is obvious that the medical adviser should keep a daily watch upon the patient—listening to the heart, examining the urine — especially for albumen and acetone—watching for and guarding against constipation, and in the many other ways which will suggest themselves during the course of the treatment; and with this careful supervision no harm can possibly come, but only benefit certainly ensue from even a prolonged course of this electrically excited exercise.

The patient begins to lose weight from the first, and a feeling of alertness, of lightness, and of general well-being replaces the lethargy from which these patients so often suffer. The effects also have a permanent character. The effect on the general health is marked from the first, and seems to be almost out of proportion to the number of pounds lost. In very stout people the treatment should last a month or six weeks, during which time I have seen twenty to thirty pounds, and in one case forty pounds, lost, the patients feeling in capital health and spirits all the time, and being all able to work or pursue their usual vocations with added zest.

The effects of this current in the treatment of obesity are immediate. I append a chart of a month's treatment in a fairly typical case.

The diet during the treatment must vary with the individual and with what he has been in the habit of eating and drinking. *Primâ facie,* with so much animal combustion going on it should merely consist of fruit, vegetables, and salad; in fact, it may be said that by the aid of this current one eats himself, and takes a little salad with it. As a rule, patients take very kindly to the treatment, and after the first few days the improvement in the general appearance and in good health is such that they are often more anxious to make the diet more strict than to raise any objections to the limitations imposed by the physician.

Although, as above stated, twenty or thirty pounds may be lost in a month or six weeks, the rate to be aimed at, for the sake of permanence, is 2½–3½ pounds a week, and as a general rule I advise a total reduction of 10 per cent. at one series of treatments. With these limits the patient may be assured of absolute safety and a feeling of increased health from the beginning and throughout the treatment. Another reason for advocating the slow rate of reduction is that when fat is rapidly reduced it tends to return, whereas the slower the rate the more permanent the effect. Yet another argument in favour of the more gradual method is that when fat is lost rapidly it is not, as a rule, lost from the abdominal walls and mesentery, where the reduction is generally most wanted, whereas if the loss of fat can be maintained for some time an equalization of the different fat deposits occurs, and it would appear that the excess of fat contained in the abdomen is gradually transported to the portions of the body where there is less fat, in addition to that which is caused to disappear altogether. There yet remain other reasons, but I think enough has been said to show that slow methods are unquestionably preferable.

One question constantly arises, and that is the action of this treatment on the heart. It can only be beneficial; but as this subject was so ably handled by Dr. Hampson before the Royal Society of Medicine in February 1912, I have asked him to add a supplementary note to this chapter, and will content myself with the statement that in the reduction of weight by this method of treatment there is one of the most valuable adjuvants to the treatment of circulatory disease we possess.

"Where the Bergonié treatment is employed primarily for obesity, it has to be carefully watched for possible secondary effects upon the heart. In suitable cases of weak, irritable, and incompetent hearts the control and improvement of the circulation can be made its primary function.

"The contraction of a muscle squeezes blood out of the veins in that muscle. The veins are provided with valves which prevent the blood from flowing in one direction, and allow it only to flow in the other. Thus every contraction of the muscle drives blood out of it, always in the same direction—that is, towards the heart. Under the stimulation of Bergonié's apparatus, a number of the large muscles contract all at the same time, and so they all at the same time send a wave of blood towards the heart. This is repeated at every beat of the metronome. Thus one result of the Bergonié treatment, which accounts for some of its good effects, already described, is the powerful assistance it gives to the circulation by reducing in the veins the pressure against which the capillaries have to deliver their contents, and so indirectly reducing the pressure against which the heart has to pump.

"A further and very remarkable effect is produced by timing the contractions in a special manner. If they are arranged to take place at almost exactly the same speed as that at which the patient's heart beats, the heart's action will presently be found to have timed itself so as to be synchronizing exactly with the rhythmical contractions. If these contractions be arranged at a somewhat slower speed than the heart-beat, the latter is soon reduced to the same slower speed. Thus it is possible to control and regulate the speed of an excessively rapid beat.

"The influence of this treatment upon the patient is in all other respects nothing but beneficial.

The re-inforcement of the circulation increases the activity of all the functions which depend upon a good circulation. In particular, breathing distress is markedly relieved, and the patient feels a sense of well-being and comfort which lasts for several hours, and becomes increasingly distinct and lasting by repetition. At the same time that more circulation work is being done, the heart is exerting itself less over doing it, owing to the assistance it receives from the contractions of the body muscles, which being stimulated rhythmically, and in synchronism with the heart itself, may be described as so many subsidiary hearts. The heart is therefore in a resting condition, and much more favourably placed for the recovery of tone and strength. Patients with dilated, rapid, and irritable heart, who had previously gone for treatment to Nauheim, and derived much benefit from it, find this application of the Bergonié method of stimulation to act more promptly in controlling the heart, and have preferred to remain under its influence at home, where the dilated heart has undergone a notable reduction in size. It is almost needless to say that the treatment must be given with the greatest caution and in constant relation to the patient's condition, which has to be most carefully observed."

CHAPTER XVI

CARCINOMA AND SARCOMA

It is with a good deal of diffidence that one approaches the subject of the treatment of these diseases by the various forms of electricity. That it has been used either by itself or in conjunction with surgery with gratifying results in some cases must be admitted, but it must also be conceded that it has signally failed in other cases. With the statement that too much has been claimed for electricity by some, one must concur, even as the therapeutic nihilism which denies electricity any place in the treatment of cancer must be combated. X-rays, Radium, Fulguration, Oscillatory Desiccation, and Cataphoresis (or Ionic Surgery, to give it its newer appellation) have all been tried, and though it is not suggested that any one of them, or any combination of them, should replace surgery, I think that each one should have due consideration, should be examined on its merits, and the question carefully considered as to whether or no it has not its own particular niche in the armamentarium useful in fighting a disease, of the nature of which we are not yet fully cognizant.

The most careful and long-continued work in this direction has undoubtedly been done by Massey of Philadelphia, who has been treating the various forms of malignant disease for over seventeen years. Any one who knows him or has worked with him at the Hospital in Philadelphia must be struck with the simple directness and careful scientific spirit with which his work is conducted. This is reflected in his books, in which a large number of cases is recorded, and the results, whether favourable or unfavourable, are duly noted. Many of these are accompanied by photographs. Massey does not claim that the method is to replace surgery; in fact, many of the cases under his care (or I suppose most cases which reach any specialist in electro-therapeutics) are the derelicts; these cases usually recurrent, pronounced inoperable and avoided by the surgeon.[1]

In cases where the growth needs an extensive incision, as in many cases of cancer of the breast, in cases of cancer of the uterus, the knife is given the preference, but where it is difficult or impossible to remove the growth with any certainty or thoroughness, then the Massey method holds out certain obvious advantages; among these are that the cancer cells are destroyed *in situ* and the edge of the growth sterilized, and operative re-infection is rendered impossible. Thus an incipient cancerous growth in an accessible situation, which has not given rise to metastasis, may be entirely destroyed and the patient cured, but Massey freely admits that where metastases have occurred "there is at present no known means of cure." The method has the advantage, too, of being bloodless, and its action leaves behind it antiseptic chemicals (oxychloride of mercury and zinc) interstitially diffused throughout the growth, thus maintaining an antiseptic condition in the slough until such time as it may separate.

Even in the incurable cases this method has certain advantages, such as lessening pain and minimizing or destroying unpleasant odour, but, as Massey says, the terms operable or inoperable must receive further consideration with ionic surgery available. The Massey method consists of the massive diffusion of the ions of mercury and zinc by a powerful galvanic current. These destroy the growth, which afterwards sloughs away, and also produce an area of sterilization at the boundaries of the malignant growth. When this current is applied, the visible portion of the tumour will shrink and soften and will change colour to a greyish white, all the living structures becoming devitalized; also any disagreeable odour disappears. These changes take place in from a few minutes to one hour, according to the size of the growth under treatment. The limits of total necrosis are easily regulated and are well defined, and become later the site of the line of demarcation when the slough is about to separate. Outside this line of demarcation an area of sterilization occurs, while outside this again we have a zone in which either the current or some well-travelled ions have aroused the physiological resistance and so produced a reaction. When the operation is finished the tumour, odourless and bloodless, appears as a greyish white mass. The patient will recover consciousness from the anæsthesia, and then a freedom from pain will be noted, though he may complain of a feeling of soreness. On the following day the zone of reaction, that is outside the sterilized area, will be red, puffy, and somewhat tender. Two days later there is a well-marked line of demarcation, which may blister, and which will give rise a few days subsequently to an odourless serous discharge which will continue until the mass separates, which occurrence takes place in about seven to twenty-one days from the date of operation; the cavity heals by granulation, and the scar formed is remarkably soft and pliable, and smaller than one would expect.

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[1] *Conservative Gynæcology and Electro-Therapeutics*, 6th Edition, F. A. Davis & Co., Philadelphia, 1909; *Ionic Surgery in the Treatment of Cancer*, New York, The A. L. Chatterton Co., 1910.

The method is extremely simple (as is the apparatus, which will be described later), and may be best understood by following the details of a major monopolar operation. The word "major" refers to where a general anæsthetic is required, and "minor" to where only local anæsthesia is produced, or the procedure is not sufficiently painful to need even this. Monopolar refers to the method when the indifferent negative electrode is placed at a situation on the patient's body as remote as practicable from the growth in which positive electrodes are inserted; the bipolar, where both positive and negative electrodes touch the tumour.

The operative technique of a major monopolar operation is as follows: taking, for example, carcinoma of the breast. The patient, having been anæsthetized, is laid upon a blanket upon which is the large dispersive or indifferent electrode connected with the negative pole; care must be taken to see that this accurately fits the part to which it is applied, and also that no part of the metal comes in contact with the skin.

The zinc needles attached to the positive pole and lying in a tray, either separately or in bundles of five or six, are now freely and rapidly amalgamated and inserted into the periphery of the growth; as a rule their sharp points will usually enable this to be done, but it is as well to have a sharp pointed bistoury at hand, especially in those cases where the growth is hard and brawny. As soon as the first needle is in place the current should be turned on very slowly and evenly by an assistant, who has nothing else to do except to attend to regulating the current and to make observations on the meter. The current is gradually increased up to 50 to 100, and at last 150 milliamperes is reached. While the current is being increased a second needle is introduced, and later a third, and so on. The current strength being reckoned at not less than 100 milliamperes and not more than 150 per needle, as the operation proceeds each needle will gradually be surrounded with an area of devitalized tissues of a dirty white or yellowish white colour. The needle, having accomplished its purpose, may then be removed, and another needle inserted in another place. It is better to use a fresh needle rather than to re-amalgamate the old one, for with a new one there is less liability for the end to break off in the growth, and while this is a matter of small importance, it may as well be avoided.

Gradually the whole of the growth is brought under the influence of the diffused ions. The time occupied will vary with the size of the growth and the number of needles it is possible to employ. When, however, it is evident to both sight and touch that the desired full effect has been gained, the current is very slowly and evenly reduced to zero, the electrodes then removed, and a dry sterile dressing applied.

It is needless to say that during the passage of the current the condition of the patient must be carefully watched—as to pulse and respiration—and should any signs occur, the current should be swiftly reduced; the rapid decrease of the current will act as a stimulant, both to the cardiac and respiratory centres.

Massey lays down the maximum amount of current which may be applied with safety by the monopolar method, and as the table is based upon many years of experience and is a valuable guide it is here appended:—

To the head, mouth, throat and neck . .	300 to 400 ma.
To the right breast and thorax generally .	400 to 800 ma.
Below the waist	800 to 1600 ma.

For the left breast it is advisable to restrict the method to the major bipolar application of it.

With the bipolar method these doses may be doubled with safety, and with even less influence on the reflex centres.

The apparatus is simple. The most convenient method of deriving the current is from a direct current main, with a specially-made resistance. In America the Massey Universal Graphite Resistance is in use and is very satisfactory, as by it the current can be turned on very gradually, and sudden changes of strength are avoided. But it has a few disadvantages in this country, one of the chief being the impossibility of immediately being able to replace it in case of need.

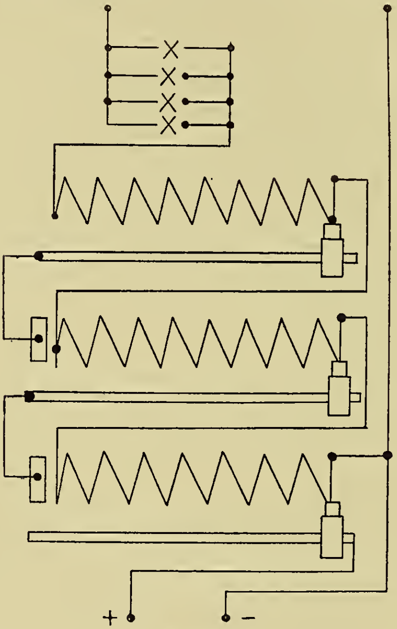

Fig. 39.

A Rheostat, which has given me satisfaction in this work, was made for me by Messrs. Schall & Son, and may be thus described (Fig. 39).

The apparatus consists of a resistance of 300 ohms, connected in series with a row of four lamps, which are connected in parallel. The whole is connected to the main supply of 200 volts. One pole of the main supply is connected to a terminal, which is the beginning of the resistance, and to which the electrode for the patient is attached. The other terminal of the patient's circuit is connected to the sliding contact of the 300 ohm resistance. The patient is therefore in shunt with the resistances, and can only receive the current resulting from the potential difference between the beginning of the resistance and the point at which the sliding contact happens to be on the first, second, or third bar of this resistance.

In using a resistance of this kind it is, of course, of the greatest importance that the patient cannot receive the full main voltage. As most electrical companies neutralize one wire, it is essential to find out which of the poles from the supply is the neutral one, and to connect the board in such a manner that the terminal at the beginning of the resistance is this neutral pole.

The following method may be employed to find the neutral pole: A lamp of about 8 or 16 candle-power is connected in series between one terminal of the patient's circuit and a milliampere meter reading to at least 500 ma. The other terminal of this meter is attached to a water-tap or gas-pipe. If the board is correctly connected, no current will be registered when the switch on the board is turned on, no matter which of the two terminals of the patient's circuit is connected with the lamp. If the board is wrongly connected the milliampere meter will register a large current, which is being consumed by the lamp, from one pole of the patient's circuit but not from the other. Both poles must therefore be tested, and if the board is found to be wrongly connected the main plug must be reversed.

The lamps act as a valve for the maximum current which can be obtained. If, for instance, four 50 candle-power lamps are inserted the maximum amperage obtainable is about 1·8, but if only two 50 candle-power lamps are used the maximum amount obtainable is half the above.

Should no electric main be available, fifty to sixty dry cells may be used. These should be freshly obtained from the manufacturer, and should be individually and collectively tested not long before the hour of operation.

The indifferent electrode or dispersing-pad should be as large as possible. It is best made by taking some canvas or crash towelling, forming it into a sack, and filling it with kaolin; when made it should measure at least 14 by 30 inches, and have uniform thickness of 1½ to 2 inches. On the side of the pad which is to be placed furthermost from the skin is stitched a metal plate 10 by 18 inches—any metal which is smooth and pliant is suitable; a rheophore is firmly attached to this, and the whole wetted and kept in a copper or enamelled sterilizer until required.

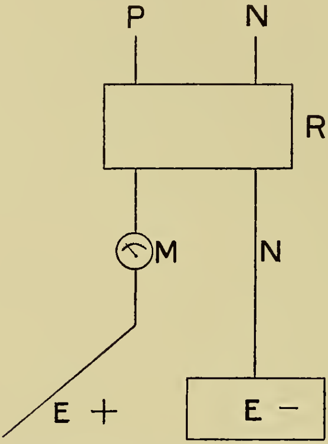

FIG. 40.—P and N representing the constant current; R, the rheostat; M, the meter; E+, the positive side of the current having passed through the rheostat and meter, ready to be attached to the active electrodes; E−, the negative pole, having come through the rheostat, is connected to the negative or dispersive electrode.

The active electrodes, ingeniously devised by Massey, are slivers of ordinary sheet zinc, $\frac{1}{32}$ to $\frac{1}{16}$ inch (1·5 mm.) in thickness. They are cut with a pair of tinsmith's scissors (though, failing these, any ordinary long shears will do). They vary in width and length according to the size and depth of the growth to be treated, usually about ¼ of an inch in width, tapering down to a point, which is rendered sharper with a file; the bared end of a piece of fine telephone wire

(No. 32 or 26 cotton-covered wire) is wound round the thick end, which is bent over it with a pair of pliers, then the electrode, with the exception of the sharp end, is insulated with sealing-wax. Immediately before being inserted into the growth this tip is dipped rapidly into a 25 per cent. to 50 per cent. solution of sulphuric acid, then into metallic mercury, and finally into sterile water. When in position in the growth it should be steadied with a small piece of adhesive plaster, from it to the skin.

These simple electrodes with the dispersive-pad are all that is required, apart from the current and the meter. At the time of the operation everything may be diagrammatically represented thus (Fig. 40).

In the major bipolar operation the large dispersing-pad is replaced by a metal electrode covered with lint or cotton wool. Massey originally used an ordinary disc electrode held in position by an assistant; finding that this had several disadvantages, he devised one made from sheet zinc. A piece is cut out shaped thus (Fig. 41).

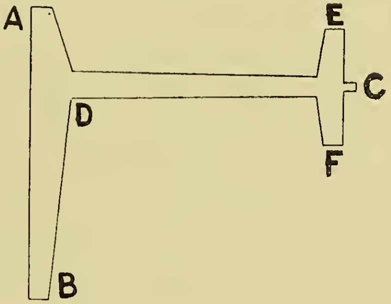

Fig. 41.

The part A B is now twisted so as to form a spiral, and a rheophore being attached to the small tip (C) at the opposite end, the remainder, D E F, is heavily insulated with melting sealing-wax. Before insulating, the part D C should be bent over so that it will rest on the skin. When completed it looks something like this:—

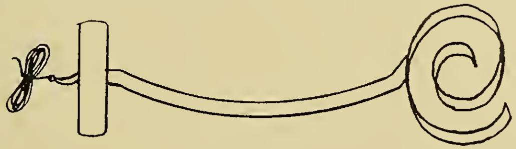

Fig. 42.

On the skin it is secured in place with strips of adhesive plaster. Within the turns of the spiral, gauze, lint, or cotton wool is packed and saturated with 40 to 50 per cent. sulphuric acid. This electrode is placed in the centre of the growth, and the positive needles applied as in the Major unipolar operation.

The minor application is used for very small growths or recurrences. It is useful in destroying any suspicious rounded granulations, or a nodular edge of a wound which shows no tendency to contract. The method is similar to that followed in the major monopolar, the current-strength in this case, however, being regulated by the toleration of the patient. Of course, the electrodes are much smaller; a basin of water forms a good negative electrode, in which the arm or leg may rest.

For fuller details Massey's own work should be consulted; it will well repay perusal, and its pictures and statistics give a clear idea of the value of the treatment. A procedure in connection with the Oncologic Hospital in Philadelphia (in which are Dr. Massey's wards) might be advantageously followed elsewhere. Each patient is persuaded to sign the following slip: "In consideration of the absolute need of full co-operation between physicians and patient that the best results may be attained in treatment, I hereby promise that when discharged from the hospital in good condition I will present myself to the surgeon in charge of my case, or to his delegated representative, at periods not less than three months apart for three years, and that if directed to return for further treatment I will make the utmost endeavour to do so." Personal experience of Dr. Massey and of his method have convinced me of its value, and, as I have already quoted, "the term inoperable must have received further consideration with ionic methods available."

Various forms of high frequency are used in the treatment of malignant disease. My personal experience of these is only that of a spectator. Foremost among them is the method first advocated by Dr. J. A. Rivière, of Paris, at the first International Congress of Medical Electrology and Radiology in 1900. The paper was entitled "Action of High Frequency Currents and of the Effluve on certain Malignant Tumours and on Tuberculosis." His method in the case quoted consisted of destroying the neoplasm by means of sparks on three successive days, after which there was a scab formation; after an interval of three days daily sittings were given, lasting one minute each; after ten days the scab had fallen, leaving a healthy granulating surface. This, as far as I know the first authentic case of cancer so treated, was a facial epithelioma. The theory of the treatment is that the thermo-electrical-chemical action destroyed the neoplastic tissue and also produced a tropho-neurotic action which is curative. It was not claimed that the method was applicable *per se* in large tumours, but that this method even in these cases formed a valuable adjuvant to the surgeon's knife. The sparks being applied at the time of the operation to the raw surface, the action in this latter case is said to be threefold:—

The sparks destroy any cancer that may be left in these surfaces.

By the contraction set up a flow of lymph is caused to wash out the area.

And the current being associated with the production of nascent ozone acts as a disinfecting and trophic agent.

From 1900 up to the present date Rivière has pursued and advocated this method. His own name for it is Alto-frequent Cytolisis, though it is more generally known under the term Fulguration. In addition to the spark derived from an Oudin resonator he uses the effluve in conjunction with them, which, though a less violent measure, exercises a similar specific action in a milder form.

In 1910 Dr. William L. Clark, of Philadelphia, read a paper before the American Electro-Therapeutic Association in which he demonstrated a method somewhat different and which he termed "Oscillatory Desiccation." This is a means whereby tissue may be destroyed by rapid depletion of its fluids. This is obtained by a specialized true oscillatory high frequency current, concentrated to a fine metal point and delivered in sparks of great frequency through an air space to the tissue. To get a satisfactory result resonance is important, and the discharge must be regular. The discharge obtained from the average coil is not sufficiently regular (as may be demonstrated by the oscilloscope), and the spark delivered is too hot and its impact on the tissues too severe. Clark had had then fifteen cases of epithelioma (including, I think, rodent ulcer), the result of which, he thought, justified him in advocating this method. He used a static machine of 12 to 24 plates, capable of 2000 revolutions per minute, driven by a 5 horse-power motor, two Leyden jars of a capacity of ·00042 M.F. each, and a resonator attuned to the capacity, one end of which was grounded and the other attached to the electrode, the milliampere meter measuring 2·5 ma. My own experience with this form of current has only been in the treatment of hæmorrhoids, but from results obtained I can well believe that small superficial neoplasms would be destroyed.

I would mention that Nagelschmidt reports success with electro-thermic apparatus described in Chapter XI.

I have no personal experience with this method in the treatment of cancer, but in order to make the subject of the treatment of this disease by means of electricity more complete, mention is here made of it.

Nagelschmidt points out, even as Massey did years ago, that in operating on a cancer it is difficult to say how often the knife cuts across layers or proliferations of the growth, and there is always a danger of transporting these cancerous cells into healthy tissue and newly open lymph channels. Now diathermic treatment, even as the zinc mercury cataphoresis, destroys the cancer cell *in situ* and coagulates and seals the lymph channels and blood-vessels, thus eliminating the danger of transplantation. To quote an article by Nagelschmidt in the Archives of the Röntgen Ray, July 1910: "It by no means follows that diathermy is superfluous in the treatment of deeply-seated tumours. In spite of the paucity of material and the slight number of experiments, we can already affirm that diathermy offers great advantages in these cases.

"Suppose, for example, that we desire to perform an abdominal extirpation of a carcinomatous uterus, the vaginal portion of which is transformed into a sloughing fungus-like growth. We commence the operation aseptically in the abdominal portion, and then, before opening the vagina, we diathermitize the whole of the vaginal portion; that is to say, we not only destroy malignant growth, but coagulate all the putrescible contents, with its streptococci and the whole of its bacterial flora. Afterwards, when the vagina is opened, we have to do with a completely sterile tumour, thus preventing infection of the peritoneum and dissemination of the cancerous germs through the sanguine and lymphatic channels. This last should be our object in all operations for carcinoma and sarcoma, and perhaps in this way diathermy may enable us to avoid the dangers of metastasis during and after the surgical operation."

Another advantage of diathermy is the possibility, by means of suitable electrodes, of causing the current to penetrate into all the corners and cavities, the osseous as well as the soft parts of regions such as the orbit or face, and thus to remove tumours otherwise inoperable. We are able to coagulate even osseous tissue, locating the action to within a millimeter of the desired depth. No blood is spilt during the operation, unless the tissue is so frail as to be broken down by the application of the electrode.

And lastly, the rôle of radium and of X-rays in the treatment of cancer must be considered, for that they have a place is now a recognized fact, though as to the importance of the part they play opinion may differ.

In certain cases, however, the use of radium is distinctly indicated—cases of deep-seated sarcoma which are inoperable, such as those placed in the upper or lower jaw, or in the sternum, or bones of the pelvis. In such cases good has followed its use, and in such it should be employed. It may be used in simple cutaneous epitheliomata without glandular complications. These heal up rapidly, and the resultant cicatrix is practically nil.

It may also be used after operation to destroy that microscopic residue which escapes after the knife; in this case, tubes of radium, one or more, are placed in the wound.

Another class of case in which radium may be used with advantage is in the presence of an inoperable cancer of the uterus; here its action is palliative. The effect of the radium irradiation upon the pain is undeniable, and usually under its influence the hæmorrhage decreases. The fœtor, too, is diminished, if not altogether abolished, and even better results than this have been reported. With regard to its analgesic action, it will be found that different intensities may have to be used, and an intensity say of 500,000 may have sedative effect on one patient, but with another a different intensity will have to be employed to get the best result. Also that radium of an intensity which has had a sedative effect on the pain has to be replaced with radium of a higher intensity as the case progresses. A book translated by Dr. Dore[1] goes fully into the matter, and may be perused with much advantage.

And, finally, coming to the action of X-rays in cancer, we come to somewhat firmer ground, for though there may be some diversity of opinion as to their value in malignant disease, few, if any, medical men to-day will deny this form of treatment *in toto* their place in the wide field of the treatment of cancer. Apart from any other diversity of opinion, it must be borne in mind that there is also great diversity in the manner in which this agent is used—such as details of dosage, filtration, &c. The lesions, too, themselves vary in many ways.

When should X-ray be used in malignant disease ?

1. When the patient absolutely refuses an operation.
2. When the growth is declared to be inoperable.
3. After the operation, as a prophylactic measure against recurrence.
4. Where all hopes of a cure has been abandoned, X-rays should be given for the relief of pain, and while it is being used, the mental sufferings of the patient may be assuaged by the thought that something is being done, and a flicker of hope, however feeble, helps to lighten the darkness of despair;
5. Where a disfiguring operation is necessary for the removal of the growth, the choice of this method should be considered; and in these cases, notably epitheliomata about the eye or nose, the cosmetic effect is usually better; it is free from risk, its application is painless, and it relieves pain from the first.

In these cases, where either the surgeon finds the case inoperable, or the patient refuses operation, the use of X-rays is decidedly indicated. Firstly, it gives the unfortunate sufferer a possibility, however remote, of recovery, and a probability of less pain and discomfort for the remainder of his life.

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[1] Dr. Dore's *Translation of Radiumtherapy*, by Dr. Louis Wickham and Dr. Defrais Cassells. 1910.

Among the cases of cancer in which X-rays may be recommended primarily one is the superficial epithelial cancer, especially that of the face situated about the eye or nose. It may here be used with a certain amount of confidence, and has certain advantages, among which are:—

Its application is painless;
its cosmetic effects are good;
it is free from risk;
it affords relief from existing pain.

Small doses employed over a long time are to be preferred to massive doses, and if an improvement be not manifest in the first three or four treatments, it should be discontinued. The reaction of the growth to the action of the rays is an indication for the continuance or discontinuance of them. The initial dose should be the largest, after which the dose should decrease; a safe dose with which to begin is a quarter Sabouraud.

The application of the ray should be kept up after an apparent cure has been effected. The cicatrix is usually quite satisfactory, being smooth and non-adherent to the underlying tissues. As to superficial cancers, in the United States rodent ulcers are classed as such, a fact which should be borne in mind in reading American literature. X-rays may be used in nodules of the skin, occurring after operation. These diminish in size and may disappear, and where they are painful, radiation has an analgesic effect. Glandular enlargements are often benefited and tend to evanesce, and with their lessened size any œdema and pain are relieved.

The failure to use systematic X-raying after the removal of a malignant growth in the light of our present knowledge ought to be considered negligent.

Post-operative raying should be regarded as an invariable corollary to every operation for cancer which the patient survives.

We know that X-rays have an inhibitive effect upon cancer—whether by stimulating the cells of an embryonic type to cells of a type of later development, or by depriving the growth of its nourishment by the obliterative endarteritis set up, or any other means matters little—therefore to ray the area from which the growth has been removed, in case there may have been some microscopic portion left behind, is a reasonable procedure.

Any precaution which can be safely taken to minimize the risk of recurrence should not be neglected. Many years must necessarily elapse before we can pronounce positively on the certainty of this method and its value in cancer.

During the exhibition of X-rays it is important that the bowels of the patient should be kept freely open. I once saw an untoward result when this caution had not been observed, the patient dying from what appeared to be an overwhelming toxæmia. The rays do appear to produce a molecular disintegration of cancer tissue and systematic absorption of some material, which may have a curative effect on the growth.

I hope that I have made it clear that it is not suggested the X-rays shall replace surgery in the treatment of Cancer of any form, but that these two agents shall be hand in hand. Surgery should remove the growth as early as possible, and X-rays should be employed to prevent its recurrence. For the patient to have the best possible chance operative treatment should not be depended upon entirely until it is too late for X-rays to do their most effective work; and X-rays should not be depended upon alone when surgical removal is practicable, but to quote Sinclair Tousey: "X-rays are a Duty in Cancer."

I hope also that the inclusion of this subject in a work on electricity may not be misunderstood. I would not have it that one single patient suffering from malignant disease should delay consulting a surgeon at the earliest possible moment, but I have felt that a disease such as cancer, upon which from time immemorial the professional mind has been taxed to its limit to discover some remedial agent, should be properly included when any agent or remedy which is to be used as a means of relief in the disease forms the subject-matter of discussion.

CHAPTER XVII

TREATMENT OF ENLARGED PROSTATE

FEW diseases from which men of middle or advanced age suffer have so tried alike the skill of the physician and the endurance of the patient as an enlargement of the prostate gland. Not only does it give rise to local troubles connected with urination, but owing to the reciprocal relation of the cerebro-spinal centres and this gland, when it is diseased various neurasthenic symptoms often supervene. Indeed, Dr. Snow stated that in men suffering from neurasthenia the prostate should usually be examined. Not only may it give rise to definite neurasthenia, but mental sluggishness often accompanies this disorder, and sometimes the only symptom of a chronic prostatitis may be inactivity of the mind. But the symptoms of enlarged prostate for relief of which the patient seeks medical advice arise from the mechanical obstacle offered to the urinary flow. There is often a feeling of a necessity to strain before the flow can be established, and when the act is apparently finished some more urine dribbles away, and this involuntary second passage may take place some few minutes even after the patient had thought his bladder was empty. The time occupied in passing water gradually becomes longer. Nocturnal urination and frequency of micturition are in most cases usual complaints. When a patient has these symptoms, apart from the discomfort he experiences, his condition is not free from danger. The bladder has lost some of its tone; it is usually distended, hence attacks of cystitis are not uncommon. The patient is liable to attacks of complete retention of urine or to septic poisoning, which may prove fatal. Such being the case, what treatment can be recommended? In the great majority of cases the patient is instructed in the art of passing a catheter, and his catheter life has commenced, and it would be a bold man who characterizes this as either free from risk or a pleasant prospect.

Drugs are of little use except to relieve the symptoms of irritation, to improve the condition of the urine, or to combat complications, such as hæmorrhage, &c., as they arise. Surgery has without doubt saved many lives and relieved this condition with operations such as Prostatectomy and Castration, but with the operative treatment of enlarged prostate (or indeed with that of any other affection which has passed beyond the reach of electro-therapeutics) this is not the place to deal. But in electricity we have an agent which will usually give rapid relief, and in some cases a complete cure. The cases must be differentiated by their respective pathological conditions. The use of electricity in this distressing disorder is comparatively little known. It was accidentally discovered by Snow some twelve years ago, when he was treating an intra-pelvic neuritis with the static wave current. The patient had a large tender prostate, which was found to be softened and reduced in size after the application of the electricity, and since then that physician says no work in recent years has given him greater satisfaction. In 1902 Dr. Snow gave me the benefit of his experience, and since then I have continuously used his method, and from my results can recommend this treatment with confidence. But before describing treatment, let us consider the anatomical characters of the condition we are called upon to treat. The structure of a hypertrophied prostate is but a slight modification of the gland itself. Histologically the enlargement is a proliferation of the constituent elements of the prostate, but in all forms of prostatitis the consistence is less firm, the texture somewhat more open and spongy; there is more fluid than natural in the gland tissue; the mucous membrane may be thinner and more vascular and the duct orifices larger.

Here it would seem we have an ideal condition for the exhibition of the static wave current. We have a structure partly glandular and partly muscular. Here we can place an electrode alongside of the diseased structure, applying it practically directly to the pathological condition. Muscular contractions are induced, the gland tissue is contracted, and the products of inflammation are squeezed out. These accumulations having been mechanically expelled, a tonic circulation is restored to the gland by the cell activity electrically stimulated. In infected cases where glass vacuum electrodes should be used we also gain the benefit of their germ-destroying effects. Each successive treatment gives more and more power to the muscular fibres, more tone to the glandular structure, leaving the gland smaller and of more normal consistence, till little is left but healthy muscle fibre and healthy gland tissue, with the exception of those cases of very long standing where the hyperplastic fibrous tissue will still persist.

The treatment already mentioned as discovered by Snow remains to-day practically the same. The details of treatment are as follows:—A metal electrode is passed into the rectum and pressed against the gland. It is attached to the positive side of the machine, the negative being grounded. The sliding rods touching each other at first are gently and slowly opened according to the toleration of the patient. The treatment continues for twenty minutes.

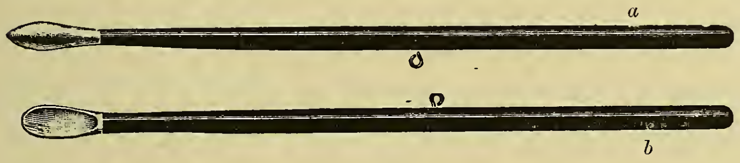

Fig. 43.

Where an infection complicates the prostatitis a glass vacuum electrode should be substituted for metal, and attached to the negative side, the positive being grounded. Special electrodes designed by Dr. Titus and others have been constructed for the purpose (Fig. 44).

Arguing from similar conditions it appeared to me that sparking the prostate should have a good effect especially in obstinate cases. To this end I had made for me an ordinary metal prostatic electrode on a vulcanite handle, half-way down which is a metal knob connected with the electrode. Thus, on the principle of Snow's spark director, a spark applied to the knob would have the effect of a spark applied to the gland. In all sparking it is superfluous to say the spark-gap should be wide open, the negative side of the machine connected to the platform by means of the shepherd's crook, the positive side and the ball being attached to separate groundings. I cannot say, however, that this gives any better results than using the ordinary electrode.

Patients will often remark, even at the end of the first treatment, that the perineal sense of weight is less, and after daily treatment for a week or ten days, and tri-weekly séances thereafter for a month or six weeks, the congestion and engorgement have disappeared, and with them the pain, discomfort, and necessity for getting up at night.

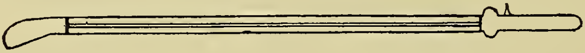

Fig. 44.

The condition of the bladder has likewise improved, and I am inclined to attribute this, in part at least, to the stimulation of those unstriped muscular fibres which are not only, as we saw, part of the prostate, but continue to the bladder. These fibres have been stimulated to contract, and with this exercise would naturally acquire more power and tone, not only in their prostatic portion, but in their vesical part as well; thus giving increased muscular force to the bladder and greater power of getting rid of the urine.

Often after one treatment it will be noted that the gland is reduced in size, is not so tender, and is softened throughout its entire structure.

The treatment should be given often enough to prevent a relapse; probably daily. After each treatment the improvement will be better maintained, and with the gland growing smaller and softer, the subjective symptoms grow less and less until they disappear entirely.

Not all cases respond to treatment with the same uniform success. In the very aged, or where there is much fibroid tissue, we can only hope for an abatement of the inflammatory process, but even here we get a marked improvement in the tonicity of the unstriped muscular fibre, both prostatic and vesical. In other cases, even where the condition has lasted for a number of years, with cystitis and difficult micturition, with the forcing out of the infiltrating exudates we get such a marked improvement that in the patient's estimation it amounts to a cure.

Iodine has been administered by ionization in these cases, but the results have been disappointing; more recently thiosinamin has been similarly used. Both these methods were introduced by Neiswanger, who lays down the following rules for the latter drug:—A large-sized prostatic gum-elastic catheter is used, in which is a galvanized iron wire stylet; round this is loosely wrapped some cotton wool soaked in a solution of thiosinamin. The end of the catheter is provided with numerous perforations. The instrument being introduced is attached to the positive pole, with the negative pole connected to a large abdominal pad. About ten milliamperes are allowed to flow for ten minutes every fourth day. I have no practical experience with this method, but it would seem worthy of a trial in recalcitrant cases.

X-rays have been used in enlarged prostate, but as I have only used them in conjunction with the static method I am not in a position to judge of their value. At the third Congress of Physico-Therapy, Drs. Perrin and Wullyamoz presented a paper on this subject, which may thus be briefly summarized. All cases of enlarged prostate are divided into five classes:—

1. Prehypertrophic or congestive cases, characterized by frequent micturition at night, morning priapism, and pain during the act of urination. There is no residual urine.
2. Hypertrophic cases associated with prostatitis.—The patient in such cases has a sudden and complete retention of urine, which disappears on massaging the prostate.

3. Hypertrophy with Residual Urine.—In such cases they find more or less residual urine after the patient has micturated.
4. Cases with Bearable Retention.—In these cases the bladder slowly and insidiously becomes distended.
5. Cases with Unbearable Retention.—Here the bladder can no longer tolerate the degree of dilatation present.

Radio-therapy can always cure patients in the stage of congestion, and sometimes ameliorates the condition of those who exhibit evidences of residual urine. In the other cases it is utterly powerless.

As a type of the way in which a case behaves when treated by the static wave, I append the case of Mr. J. P., age sixty-five, who consulted me on September 22, 1911. About six or seven years ago he noticed more than ordinary frequency of micturition, especially at night. This apparently got a little better, but lately it is troubling him acutely. He gets up at least five times a night to pass water. He can retain urine for four hours at a time during a day, but it is more comfortable to pass it every two hours or so. Also the patient complains bitterly of a second flow (involuntary) some minutes after finishing micturition; also, there is a discomfort before and after micturition, and a dragging sensation during the day. Patient also has pain in the back which he calls lumbago. Physical examination showed that an enlarged and fairly hard mass apparently occupied the whole of the prostate, and was of about the size of a hen's egg. There was nothing in his history or general health to call for comment except that he never had had any venereal disease, and he had a maximum arterial tension of 200 millimeters.

The treatment was instituted at once with the wave current in the prostate, and after twenty applications, on the 9th of November, treatment was discontinued, the prostate being about half the size that it was on September the 22nd.

The records for these days were as follows:—

DATE 1911	RETIRED TO BED.	DISTURBED FOR MICTURITION.
Sept. 22*	11 P.M.	
,, 23*	11 P.M.	No change.
,, 24*	11 P.M. (Discomfort after micturition less. "Lumbago" pain gone. Frequency of micturition the same.)	No change.
,, 25*	11 P.M.	4.30 A.M.
,, 26*	10.30 P.M.	4 A.M.
, 27*	11 P.M.	12.30, 4, 5.30 A.M.
,, 30*	10.30 P.M.	5 A.M.
,, 31		1.30, 3, 4.45, 6 A.M.
Oct. 3*		3.15, 5 A.M.
,, 4		5.45 A.M.
,, 5*		1.30, 3, 4, 5, 6 A.M.
,, 7		1.45, 6.15 A.M.
,, 8		4.45 A.M.
,, 9*		2, 5 A.M.
,, 10*		4.30, 6.30 A.M.
,, 11	11.45 P.M.	3.15, 5.30 A.M.
,, 12	11 P.M.	5.30 A.M.
,, 13	11 P.M.	4 A.M.
,, 14	11 P.M.	3, 6 A.M.
,, 15	11 P.M.	12.15, 1.45 A.M.
,, 16*	11 P.M.	3.15, 6.15 A.M.
,, 17*	12 P.M.	4.15, 4.45 A.M.
,, 18*	10.45 P.M.	5.30 A.M.
,, 19*	11.45 P.M.	4.30, 6.30 A.M.
,, 20	10.45 P.M.	1.45, 6 A.M.
,, 21	11 P.M.	2.30, 6.30 A.M.
,, 22	11 P.M.	2.30, 6 A.M.
,, 23*	11 P.M.	3.15, 6.45 A.M.
,, 24*	10.45 P.M.	3.15, 5 A.M.
,, 25*	10.45 P.M.	5.30 A.M.
,, 26*	11.15 P.M.	3.30, 6.30 A.M.
,, 27*	11.15 P.M.	1, 5.30 A.M.
,, 28	11.15 P.M.	4.45 A.M.
,, 29	11 P.M.	3.30 A.M.
,, 30	11 P.M.	2.30, 4.30 A.M.
,, 31	11.15 P.M.	3.30 A.M.
Nov. 1	11.15 P.M.	3.45 A.M.
,, 2*	11.15 P.M.	6.15 A.M.
,, 3	11.15 P.M.	6.30 A.M.
,, 4	11.30 P.M.	7 A.M.
,, 5	11 P.M.	5 A.M.
,, 6	10.45 P.M.	2, 6 A.M.
,, 7	12 P.M.	6.30 A.M.
,, 8	11.15 P.M.	4.30 A.M.
,, 9*	11 P.M.	4 A.M.

The asterisk (*) denotes days on which patient had treatment.

The patient arose each morning at 7.30, when he passed water. From this it will be seen that from the end of October the patient was disturbed but once nightly.

When we come to consider that about one-third of men at sixty suffer from an enlarged prostate, though perhaps only half of these have symptoms of the disease, and when it is realized that little can be done by medical means, that later the patient is faced with the operation of prostatectomy or castration; then if we can by static electricity give the patient even a chance to avoid these in the future, and a catheter life in the present, the case for the employment of static electricity to deal with enlarged prostate is made out.

CHAPTER XVIII

TREATMENT OF LUMBAGO

Lumbago I have seen defined as muscular rheumatism affecting the muscles of the back, but if this were the truth, the whole truth, and nothing but the truth, this section would be much shorter, more satisfactory, and more complete than, I fear, it will be. The term "Lumbago," like charity, covers a multitude of sins, and the variation in the pathological conditions makes treatment and prognosis very difficult.

Some years ago a medical confrère once remarked to me when he heard that I had been asked to read a paper on this subject, "I hate to see a case of lumbago come into the room; at one time you get a brilliant success, and the next time, with an exactly similar case, you can do no good." If we define lumbago as a pain in the back like rheumatism we shall meet "exactly similar" cases.

It is necessary to be in a position to differentiate between the various conditions known under the name of lumbago to indicate the appropriate forms of treatment.

Etiology.—As regards the etiology of lumbago, the attack can usually be traced to exposure to cold and damp, sometimes to trauma, with possibly a gouty or rheumatic diathesis present. As has been frequently pointed out, the onset is usually acute, but in reality it supervenes on a chronic condition, either latent or known to the patient.

Pathology and Diagnosis.—Gowers set forth the theory that lumbago is due to an inflammation of the fibrous tissue, with which the different nerve endings (muscle spindles) are surrounded. But, as a fatal result of lumbago is (as far as I know) unrecorded, any real knowledge of the actual pathological condition is still a matter of conjecture.

It is not easy to differentiate the pains of lumbago, the generic term which the patient uses to describe his sufferings. If the pain be worse when the patient bends forward in the act of lacing his shoes, the pathological lesion is probably in the psoas and quadratus attachments; if it is worse in straightening himself up, the erector spinæ muscles are involved.

If there be an intense pain from the sacrum to the third dorsal vertebra, not increased on spinal movement, Schraber notes that this shows the implication of the fascia lumbo-dorsalis. Pain on rolling the thigh upwards shows that the psoas muscle is involved, but the trouble rarely happens in the psoas alone; the quadratus is almost always similarly affected. When there is pain in the back from the fourth to the seventh ribs, which is increased by deep inspiration and uninfluenced by bending, the serratus posticus is the offending muscle.

When movement increases the pain in the muscles, pelvic or renal disease may be excluded, as a rule, from the diagnosis.

The neurotic spine, sacro-iliac disease, the pain from a loaded colon and from hæmorrhoids, cancer of the spine, and cancer of the sacro-iliac notch, are easily excluded as a rule.

I have seen one case, referred to me as lumbago, which proved to be referred pain from an enlarged prostate, and which entirely disappeared as the prostatic condition improved.

The violent backache which ushers in dengue, influenza, and other conditions of toxæmia, although it is markedly aggravated by movement, is easily differentiated from lumbago by the elevated temperature which always accompanies these disorders. Lumbago may be mistaken for reflex troubles and affections of the vertebral column, more especially a periostitis.

Persistent lumbago may be confounded with Pott's disease of the spine, or with sacro-iliac disease (which two conditions are practically identical). Here the pain may be confined to the lumbar region, or may radiate down the sciatic nerve, even as in lumbago.

Examination per rectum will assist in the diagnosis, since it may reveal tenderness in the region of the sacro-iliac articulation. Also pain will be elicited when the sides of the pelvis are pressed together, and there may be local swelling and temperature.

Sacro-iliac relaxation is sometimes the true pathological condition to be found when the patient comes complaining of lumbago, more especially as here, too, the pain may be referred along the sciatic nerve (this, of course, being due to the involvement of the lumbo-sacral cord passing over the upper part of the articulation, and the pain caused by the tension thus induced). In a patient suffering from this relaxation there is no pain on pressure of the sciatic nerve nor over the lumbar muscles, which can also move without pain, although a rectal examination may reveal a tender spot in the region of the articulation. There is not only no pain when the sides of the pelvis are pressed together, but while so pressed the pain previously complained of is less or absent.

I have dwelt at some length on the sacro-iliac joint, for it is here that we often encounter a point of obstinacy in the disease, which I have sometimes diagnosed as a rheumatism of that synchondrosis. Lumbago, I believe, as Dr. Luff pointed out at the Polyclinic (London) in 1909, commonly begins as a localized affection of the insertions of the muscles in the vicinity of one or both of the sacro-iliac joints, and spreads by continuity of the fibrous tissue, as is manifested by its affecting the tendinous attachments of the neighbouring muscles, by its affecting the sacro-iliac joint itself, and by its often spreading through the joint and reaching the sheath of the sciatic nerve.

But, perhaps, though far from exhausting the subject, I have said enough at present on the subject of pathology and diagnosis of lumbago.

Treatment.—The subject of treatment is on a more satisfactory basis, and one turns to it with comparative relief. The treatment of lumbago is usually successful; to those familiar with electro-therapeutic measures I have nothing new to offer, but in order to complete the outline of the subject, I will briefly recapitulate the treatment I am in the habit of employing. Firstly, I see that the bowels are freely moved with a saline, possibly preceding it with mercury. I also order:—

℞—Sod. Sal. Gr. 20.
Sod. Cit. Gr. 30.
M. mitte tal. No. 6.
Sig.—To be taken in a glassful of hot water every four, five, or six hours.

This prescription was given me by Mr. A. H. Tubby years ago, and I have found it invaluable. As much heat as possible with a hot-water bag over the seat of the pain is also indicated.

When the patient can continue to come and see me I apply radiant light and heat with the 500 candle-power incandescent lamp for fifteen or twenty minutes, followed by the static wave current for the same length of time.

This is to my mind the ideal treatment. In some few cases where I deemed it not advisable to use the wave current I followed the exhibition of the light with ionization, using a very hot 2 per cent. solution of lithium iodide, to which I added a few drops of tincture of iodine, so as to get an excess of iodine, using a current density up to 1 ma. per square cm., according to the toleration of the patient. In one case, when the patient could not stand iodine, I administered salicylic ionization, and obtained marked relief from pain, but ionization has not yielded me anything like as good results as has static electricity.

In some cases mechanical vibration, the static indirect spark, the high frequency effluve, the condenser vacuum tube, or diathermy, will be found to be of use; but where possible the high candle-power lamp, followed by static wave current, is in my opinion much to be preferred, the light dilating the capillaries and causing diaphoresis, while the wave current tends to remove the infiltration, squeezing out the serous exudation from the tissues; all of which actions diminish the pain.

When the patient cannot come to me, I advise freezing the skin over the painful area with ethyl chloride (if this be not immediately successful it is not to be repeated). If this fail, acupuncture is sometimes attended with astonishing results; the skin, having been washed with soap and water, is swabbed over with iodine, when needles, which have been sterilized in a flame, are plunged in the painful points of the muscles and allowed to remain twenty minutes to one hour. Sir James Grant states that possibly the needles set free an excessive storage of electricity which has accumulated in the muscles.

If the patient be going on a journey, strapping with adhesive plaster affords great relief. The patient is strapped as much as one would strap for a broken rib, only of course lower down over the seat of pain.

The internal administration of iodine is much recommended, but I am glad to say that hitherto I have failed to encounter any case of lumbago which did not yield to the therapeutic agents I have described.

Many illustrative cases could be instanced, but I should like to quote two typical cases.

Mr. H. A., age 56, had suffered from lumbago for ten years. He was never entirely free from pain, and sometimes it became so severe as to prevent him attending to his business. It was during one of these acute attacks that he was referred to me. On examination there was the typical pain of muscular rheumatism. Every movement would elicit an expression of pain. At the end of thirty minutes combined application of the 500 candle-power light and of the static wave current the acute pain had gone, and the patient could move in comfort. Patient, though very pleased, complained that there still remained some pain in the form of a dull ache, which appeared to be over the sacrum and up to the level of the third dorsal vertebra. He came fourteen times in all. The acute pain returned some three or four times—each attack being of lessening intensity, with gradually lengthening intervals, until they ceased entirely. The dull ache gradually improved till there remained only an occasional linear pain, corresponding to the sacro-iliac synchondrosis. The patient is now in a condition of freedom from pain altogether, except when he is much fatigued, when the ache in the synchondrosis will temporarily recur, but disappears without treatment.

Here we had a true myalgia supervening on a chronic affection both of the fascia and of the joint, with possibly some thickening round the latter. The patient in my opinion will be liable to relapses, which should readily yield to treatment.

As a typical case of simple lumbago I may cite that of Mr. D. L. R., age 30, who came to me in October 1909, his doctor saying he had had lumbago for four days. He moved with a good deal of pain, and stepping on to the insulated platform caused him to cry out. At the end of twenty minutes—Static wave current, 8 in. to 10 in. spark-gap, with an electrode 10 in. by 8 in.—patient stepped down, saying that he had no pain whatever. The patient returned on the following day, with a feeling in his back which he described as more of a discomfort than a pain. The treatment was repeated, complete relief obtained, which has been maintained up to the present time (three years later). I do not anticipate any return. It would be easy to extend the recital of the successful treatment of lumbago, but there are few, if any, medical practitioners who could not similarly recite cases; however, as far as my experience goes, the most brilliant results are obtainable in the way here indicated.

CHAPTER XIX

SCIATICA AND SYNOVITIS, AND THE MANNER IN WHICH STATIC CURRENTS ACT

Introduction.—It may seem that the subjects embraced in the title of this section are so widely distant that no one therapeutic measure could be satisfactory as a curative agent.

But the fact remains that static electricity is alleviating these conditions in hundreds of cases to-day, and I am going to try and show how and why it is so.

I propose, firstly, to recapitulate in a general way the manner in which certain static currents act; secondly, the anatomical characters of the two conditions I have named; and, thirdly, to show how, by the very nature of these currents, they must relieve the pathological conditions of the disease.

The Manner in which the Static Currents act.—Static currents induce physical activity. A departure from physiological health means some lessening of physical activity, either local or general, whereby metabolism is impaired.

Mechanical Effects.—Perhaps the most important attribute of static currents is their mechanical action. They cause tissue contraction—not only the contraction of surface structures which can be seen, but also of the protoplasm within. The contractions so produced vary from a coarse muscle movement to the finest cellular and protoplasmic changes of form. Therefore, it is not difficult to understand why they should improve conditions of faulty metabolism and lessen or remove the stasis upon which all non-infective pathological conditions depend, and which is the usual concomitant of infective inflammations as well. Take for example the static spark—the oldest of static modalities. The body being charged from the static machine, the whole of this charge is suddenly focussed at one point and there discharged. There is enormous activity developed along the path by which the current travels, increasing up to that point at which it is discharged from the body, where the energetic contraction produced by the current is at its maximum. With such contractions, stasis cannot long exist, and the fluids from infiltrated areas must be forcibly expelled. With the expulsion of the infiltrating fluids, and the removal of the stasis, a healthy cell activity is induced, and a physiological condition replaces the pathological torpor.

The local effects of these currents can be seen where the stasis is visible, and the effects of the removal of the stasis can be noticed where the stasis is in a deeper part of the body.

That the current is constitutional as well as local is evidenced by the increase of the elimination of urea and other extractives, the production of perspiration, the alteration in arterial tension, the increase of carbon dioxide, and the general feeling of *bien-être*, which can easily be converted into fatigue and lassitude when too large a dose has been administered.

The mechanical action alone renders the static currents too valuable a method of treatment to be neglected, and is a satisfactory refutation of the suggestion of those who would credit this valuable weapon with psychic ability only. Safe, sure, and satisfactory in almost all non-infective inflammations, static currents will be a revelation to those who have not used them.

Electrical Effects.—Another way in which static currents work is by means of their electrical effects, which produce in the tissues an active metabolism. Electrolysis, such as we know it in the constant current, is here so small as to be a negligible quantity; the amperage is too low and the diffusion too great to allow of it.

The electrical effects are partly due to the polarization of the cells through which the current passes, and partly again to mechanical action. The current may be compared to a breeze blowing through a field of corn, and in its passage producing cell activity, upon which active metabolism is based.

Polarization of the cell elements will also induce a cellular activity or cell gymnastics according to some authorities. D'Arsonval has observed a change of shape in a cell traversed by the current. In fact it would be difficult to imagine a current traversing the tissues without electrical stimulation taking place.

Chemical Action.—There is undoubtedly some chemical action in these currents, but as it does not affect the two diseases under consideration, it can be left alone for the purposes of this section.

Actinic Effects.—The actinic effects of high potential currents when administered from glass-vacuum electrodes contribute in no small measure to their utility. Like other forms of light, the discharges from glass vacuum tubes have the power of destroying some of the bacteria. The light acts as a stimulus to the animal functions. It also stimulates the action of unstriped muscular fibre. When applied to the skin, the first effect noticed, at the place where the tube is in contact, is the production of a hyperæmia, and the blood thus drawn to the surface is immediately brought under the actinic activity of the current.

Thus, under the head of actinic effects we have not only their germicidal properties, but also their power to aid faulty metabolism by increasing the oxidation power of the tissues.

Neuritis (Sciatica).—Now taking up the two diseases at present under consideration, in both we shall find that a congestion or stasis is either a cause or a complicating concomitant. To begin with, neuritis, taking sciatica as a type—and parenthetically I may remark that I believe that a great majority of neuralgias should be classed under the head of neuritis, and in any case static electricity forms a valuable diagnostic differentiation between these two pains—let us see what are the anatomical characters of neuritis. Dr. Charlton Bastian thus gives them:—

The Anatomical Characters.—We have an inflammation of the nerve sheath or of its interstitial tissues. The neurilemma, or connective tissue sheath of the nerve (including its minute prolongation between and around separate bundles of nerve fibrils) become much hypertrophied, and on microscopical examination there is to be found, in addition to the increased vascularity, a multiplication of new tissue elements and the presence of migrated leucocytes. These changes may cause considerable swelling of the nerve sheaths, and may thus produce mere irritation or more or less compression of the nerve tubules, according to the amount of new elements which accumulate in, or are produced within, the nerve sheath. This condition seems to obtain in a small portion of the nerve only, one, two, or three inches, although the pain may be felt in any part of the nerve or even in its whole length. In brief, the changes which occur, and which give rise to the pain, are: (1) Increased vascularity; (2) Some amount of exudation of serum; (3) The migration of leucocytes.

Argument.—Such being the pathology, what takes place when we apply the current, and why does it relieve the pain? With the tissue contraction caused by the current the hypertrophied neurilemma returns to its former size. The multiplicity of new tissue elements and the migrated leucocytes are by the mechanical action squeezed out and by the tone imparted by the current are kept from returning, to a greater or lesser extent. The stasis being removed, repair begins to take place. The nerve tubules, no longer being subject to pressure, since the new elements which had accumulated have been forced out, recover their normal healthy, painless condition. The exudation being dispersed, the blood-vessels recovering their healthy tone, and the increased vascularity being no longer present, pressure is removed and pain no longer felt.

Details of Treatment.—The treatment has not altered since Morton and Snow first published an account of the then new wave current. As I have already stated, the cause of the trouble is usually confined to a small area. This area may be found by applying short sparks along the course of the nerve. The patient will tell the exact position of the lesion. This having been found, an electrode should be cut from a piece of metal composition. In size it should be somewhat larger than the area involved. This should be bandaged firmly to the site indicated, and attached by a copper wire to the positive side of the machine, the negative side being grounded. The spark gap being closed, the machine started, and everything in readiness, the spark gap should be cautiously opened, for at the beginning of a treatment pain will prevent the patient taking much current. After the first few minutes, a toleration more or less marked will be established, and the spark gap may be lengthened accordingly. It may be necessary, especially in long-standing cases, to apply the static indirect spark. Here, if possible, the patient should point out the painful area, which should be marked with a dermographic pencil, and a few sparks directed to that point. When the pain is relieved there, the patient should place himself in such a position that by stretching the nerve, the pain is caused elsewhere along its course. These areas should be sparked in turn. Often after a few minutes of this treatment the pain will be relieved, and in all cases, if the pain be severe enough, a few well-directed sparks may be given, with the spark director, if preferred. These sparks should be given not only to the site of the lesion, but along the whole course of the nerve.

As stated elsewhere, at the first treatment, or possibly the first three or four treatments, the affected area may advantageously be exposed to the rays of the high candle-power lamp.

The effects of a single treatment, to anyone who has not previously seen it, appear miraculous. The treatment should be repeated according to the length of time in which the pain returns. Sometimes it is necessary to begin with treatments twice a day, and to keep this up for two or three days, then drop the treatment down to once a day, and finally two or three times a week. Pain is relieved from the first treatment, and the time before which the final cure is attained would appear to depend upon the length of time during which the neuritis has existed.

Synovitis and some other Painful Joint Affections

Anatomical Characters.—Synovial membrane is perhaps more ready to inflame than any other tissue in the body, and with inflammation comes serous effusion. Joint affections usually begin in the synovial membrane, although it is true they may begin in the bone, or in the cartilage, or even possibly in the ligaments. Let us take these separately. In the synovial membrane there is inflammatory congestion (evinced by loss of its satiny polish). The synovial membrane is injected and thickened. The synovia is increased in quantity and mixed with inflammatory exudation which is poured out with it.

"If the disease progress favourably these products are completely absorbed" (Erichsen).

If the disease be in the bone, erratic exudation takes place, often becoming purulent, while the exudate interferes with the blood-supply to the bone.

In cartilage we have an increased cell development with disintegration of the hyaline substance. The cartilage cells enlarge, the matrix softens and disintegrates in various ways. The ligaments are often affected by the extension of the inflammation to them from the synovial membrane. In the ligaments under the microscope we see the bundles of fibres separated from each other by coagulable inflammatory exudation. And the soft parts in contact with the ligaments are often œdematous, especially in the earliest stages.

Argument.—To those who have followed me thus far, argument is almost superfluous. Here we have a congested synovial membrane, and inflammatory exudation, a stasis, possibly a faulty metabolism set up in the cartilage, perhaps an exudation into the tissues. These on the one hand, and, on the other, an agent which will by its mechanical action disperse that congestion in the membrane, induce a healthy metabolism in the cartilage, and so improve the circulation that these products are readily absorbed.

"If," says Erichsen, "the disease progress favourably, the products are completely absorbed." Static electricity hastens the absorption of the morbid products—that is, it compels the disease to progress favourably.

Details of Treatment.—The anterior surface of the joint, or, indeed, all of it, is covered with a thin sheet of metal composition made to fit the joint as neatly as possible. In some cases a canvas bag filled with kaolin, to which is sewed a piece of metal, will be found less painful and more adaptable to the uneven surface. In either case it is connected to the positive side of the machine, and the wave current already described is given for twenty minutes. The number of treatments depends entirely upon the extent of the anatomical changes taking place, and should be continued until all pain and swelling have subsided, and the patient is of opinion that the injured joint is as good as it was before the trouble commenced.

The disrupto-convective current, or brush discharge, I have found very useful in these cases, especially with timid and nervous patients. Here of course the platform is connected to the negative side of the machine, and the wooden electrode or ordinary whisk broom as well as the positive side of the machine each to a separate grounding. The wave current in the joint affections is a valuable diagnostic agent, for while sprains, synovitis, rheumatic and gouty joints are improved by it, malignant disease and tubercular and streptococcal infections are either uninfluenced or made worse, treatment giving rise to much pain.

At the end of twenty minutes a knee-joint which before treatment was painful, stiff, and distended with fluid, will have become less painful, easier to move, and the amount of fluid will have visibly decreased. In chronic synovitis with effusion, the wave current is very effectual in reducing the amount of fluid, and consequently increases the motility of the joint.

To briefly recapitulate the way in which static currents act:—Mechanically, by stimulating contractions, not only in the skin and muscles beneath, but also in the very cells themselves, thus relieving stasis.

Electrically, by the polarization which produces cell activity and by the surging through the tissues of the current, producing that cell activity upon which the principle of tissue health is based.

Actinically, by the germ-destroying effect of light, by the possible diminution of certain toxins, and by the increasing of the oxidation processes.

Comparing these effects of static currents with the pathology of the majority of diseases, it is easy to see the reason why the current should benefit the tissues. Just as almost all pain is due to pressure, so almost all disease is due to, or is accompanied during its course by, congestion or stasis. If this be granted, then the case for the use of these currents needs no further argument. Given on the one hand a stasis, and on the other a current, which by its mechanical action contracts the tissues around it and the cell elements themselves, and by its electrical power produces that cell activity during which it is impossible to conceive the existence of stasis, the chemical and actinic effects, destroying any germ process which may complicate the stasis, and also further stimulating the tissue activity:—given the stasis, apply these currents, and the stasis must be relieved, and with the relief of the stasis comes the relief from the disease, of which the stasis was either the cause or complicating concomitant.

CHAPTER XX

SKIN DISEASES

MOST forms of electricity have been used in the practice of Dermatology, and most skin diseases have been submitted at one time or other to electro-therapeutic methods, but here I propose to mention only such diseases as have come under my care, and only such methods as have proved successful in treating them. Perhaps one of the most commonly occurring, as well as the most satisfactory to treat, is—

Acne Vulgaris.—Here we have a constitutional condition (often some gastro-intestinal disturbance) and a local condition: (i) a relaxed flabby condition of the skin due to lack of tone in the cutaneous muscles; (ii) a greasy skin, due to hypersecretion of the sebaceous glands; (iii) comedones and pustules, follicles dilated and filled with inspissated contents in which suppurative changes may occur.

All of these factors must be borne in mind in treating the disease, and it is easy to see why any *one* form of treatment, be it local, dietetic, or medicinal, is apt to give disappointing results. True it is that a certain number of cases tend to get well spontaneously, but these cases often pay the penalty for procrastination, of scars and deep and often pigmented pitting.

This is not the place to enter into the question as to the way in which to quiet the digestive disturbance, or to discuss the appropriate diet in these cases (essential as they are to successful treatment); but I would point out the advisability in all of these cases of testing the urine for Indican, and if it be present, doing very little local treatment until the faulty metabolism of which it is an indication has been put right.

Locally the comedones must be removed by expression, and the pustules emptied by minute incisions. If the pus in these latter is not near enough to the surface, a small piece of mercurial plaster, in which has been incorporated 5 per cent. Acid Carbolic, applied for twenty-four to forty-eight hours, will materially aid matters. As much of this surgical work as possible having been done, the face should be made hyperæmic: and the two methods which I have employed are the high candle-power lamp, and the high potential vacuum tube from the static. Sometimes I have used these singly, and sometimes following the incandescent light with the static treatment. Both the rays from the high candle-power lamp and the high potential vacuum tube discharge are bactericidal, but I am inclined to think that their curative effect is for the greater part due to the hyperæmia induced, for, by its very presence, it prevents extraneous infection, and brings leucocytes to the part where they do most good. Whether these leucocytes act *quâ* leucocytes, or whether they bring with them necessary material for the formation of antibodies, or whether an autogenous vaccine is produced *in situ* must be left to the vaccine specialist; and here it should be mentioned that in acne, vaccine therapy is singularly successful.

The method of using the high candle-power lamp in facial acne is as follows: The patient, whose hair should be protected with a towel, is to be comfortably seated on a stool, or the edge of a couch, with eyes shut. The lamp should be taken in his two hands, with their backs towards each other, and the face slowly moved from the back of one hand to the back of the other, exposing first one cheek, then the forehead, and lastly the other cheek, as the head is swung from side to side. The whole treatment lasts from fifteen or twenty minutes to half an hour, with perhaps one or two intervals of a minute to rest the patient.

The duration of each treatment depends upon the amount of hyperæmia produced; the length of time required to produce a full dose varies very much with the individuals.

The treatments should, as a rule, be given thrice weekly, but this must vary with the rate at which the successive crops of eruption appear. As a rule, these gradually appear in smaller numbers and farther apart as the treatment progresses.

The application of the high potential vacuum discharge is made in the usual way (for technique, see chapter on high potential vacuum) with the surface electrode.

The electrodes should be varied from time to time, sometimes a high tube being used, and sometimes a low one. The current not only acts as a bactericide and a producer of hyperæmia, but it stimulates the flabby skin, and restores tone to the superficial muscles.

This treatment should be given thrice weekly, and in obstinate cases will require to be extended over four to six weeks. Mild cases, it is true, yield more readily, and the treatment seems to confer an immunity; so that recurrence is improbable. Another advantage of the vacuum tube treatment is that many of the old small scars and pitted marks disappear during the course of treatment, and the face generally soon shows a healthier, fresher appearance.

X-rays have a most decidedly favourable effect upon acne —a fairly soft tube should be used—the hair, eyebrows, and eyelashes should be shielded, and a Sabouraud dose may be given once in four weeks to each cheek, to the forehead, and to the chin; where feasible each dose should be divided into three or four, and so applied to each area. This not only avoids any risk of violent reaction, but appears to be more successful generally.

A powder which I have found very useful in overcoming the greasiness of the skin in conjunction with this treatment has the following formula:—

℞.

Ac. Carbol.	10 parts.
Powd. Camph.	40 ,,
Powd. Talcum.	100 ,,
Powd. Burnt Alum	350 ,,
Kaolin	10 ,,
Prepared chalk	50 ,,

This may be used two or three times during the day, and at bedtime, being gently rubbed into the skin.

Other forms of electricity have been recommended, but I have not yet found a case which failed to improve when treated on these lines.

Eczema.—The form of Eczema in which electricity is most useful is fortunately the form which is most troublesome, viz. Eczema Chronica, especially where it is accompanied by itching and induration.

The forms of electricity which will be found most useful are the static brush discharge, the high candle-power light, and X-rays. The itching is relieved and the induration softened from the first few treatments. It is difficult to dogmatize as to which of these three remedies will do best in any particular case, and experience will not always enable one to chose the most appropriate agent. But if the brush discharge do not give relief at the first two or three sittings, then it should be changed to one of the other methods. No one of the three can do any harm in this condition, which is usually much benefited by one or more of them.

Furunculosis, Boils, Carbuncles.—Much that was said about acne vulgaris applies equally to these disorders. The high candle-power lamp here, especially in cases of carbuncles, is of great diagnostic value. If, when it is applied to the lesion, pain is increased, then it is certain that the suppuration is so far established that surgical interference has become necessary; if, however, the pain is not increased, but rather diminished, then we may say perseverance with electricity will be rewarded by the carbuncle being aborted. In carbuncle as well as in furunculosis, and in boils, electro-thermic penetration, the high potential glass vacuum and X-rays, as well as the high candle-power lamp, are invaluable. The brush discharge may be used not only to abort the lesion, before pus has formed, but also to dry it up, and promote rapid healing after it has been opened. After it has been opened and has healed over, the use of the glass vacuum current will obviate to a great extent any subsequent scarring. Where the boil or carbuncle has a deep abscess cavity, it is good treatment to fill this with a solution of Copper Sulphate, and to pass in copper wire attached to the positive pole; the negative dispersive pad being placed indifferently on the back or chest, or in a bowl of water in which the hands are immersed. If the cavity be not suitable to hold the fluid, the metal may be placed in the hollow without the solution. The amount of current used will naturally vary very much with the size of the electrodes, but it should be of sufficient strength for a greenish deposit of oxychloride of copper to be easily seen on the walls of the cavity. The electro-therapeutic treatment of these diseases yields results which will be found most satisfactory.

Herpes.—In many cases of this disorder a good deal of relief may be obtained. In the early stages, hyperæmia, as intense as possible, should be produced. This may dilute some of the toxins affecting the nerve, or dissipate some microscopic stasis along its course. The lamp should be similarly applied over the posterior nerve-roots, where the hæmorrhagic inflammation of the ganglia is destroying the cells. Here, certainly, if by the hyperæmia induced we can relieve the pressure, some of the degeneration may be arrested.

In later stages the brush discharge applied to the vesicles aids materially in drying them up, and minimizing the risk of their contents becoming purulent.

When healing has taken place, the early application of the glass vacuum tube and vibration massage will help materially in reducing the risk of scars. Even in the most formidable variety where the herpes corresponds to the entire area supplied by the distribution of the ophthalmic division of the fifth nerve (where the gasserian ganglion is involved, and scarring is said always to follow), it may be reduced by careful and persistent treatment to such a minimum as to be barely noticeable.

For the obstinate and severe pain which unfortunately accompanies or follows the complaint, I have derived great advantage from X-rays, using a tube of medium hardness over the place where the lesion was and over the posterior nerve-root corresponding to it.

The static wave current and static sparks are valuable means in the relief of these pains and for removing the muscular spasm which often accompanies this condition.

Hyperidrosis, Bromidrosis.—That form of these disorders in which the disease is purely local is the only variety in which I have used any form of electricity—where there is excessive sweating, offensive or otherwise, in regions such as the soles of the feet, armpits, or palms of the hands. The systematic exhibition of X-ray produces the most satisfactory results. This is, of course, due to the effect of the rays on the sweat glands decreasing their activity and causing them to atrophy.

Hypertrichosis.—Of the two electro-therapeutic methods for the removal of superfluous hair, electrolysis and X-ray, the former has stood the test of time, and though it is tedious, the results are uniformly successful. In certain cases where the growth is so thick that electrolysis appears a never-ending task, X-rays may be employed. The chief objection to their use are—(i) a shiny appearance of the skin may result; (ii) a pigmentation, especially in brunettes, may follow. The best method of procedure, however, if the rays are decided on, is that perfected by my colleague, Dr. Wm. Hampson, who has kindly furnished me with the following particulars:—

"The employment of X-rays for the removal of superfluous hairs from the faces of women is very similar to its use for tinea barbæ in the case of men's faces, or tinea tonsurans in the case of children's scalps.

"In deciding the question, what is a suitable case, and how extensive should the operation be, it is well to remember that an epilation by X-rays, which is going to leave the patient secure against a return, will also leave her skin more or less shiny and absolutely devoid of the downy hairs which, though not seen unless closely looked for, are nevertheless necessary to the appearance of a perfectly healthy and normal skin. The growth upon chin, jaws, and neck may be so strong that the need for removal is beyond question, while that upon the upper lip is not greater or more conspicuous than is often seen in women of very good appearance. In such a case it is better to confine the treatment to the parts which absolutely require it than to run the risk of producing in the conspicuous position of the upper lip a glazed surface which would be a greater disfigurement than a mild moustache. When the moustache is really strong, there is, of course, no room for hesitation.

"The method of treatment is a modification in certain respects of that applied in epilation of the scalp, the difference depending on the greater irregularity of the surface to be treated. The scalp is nearly globular in outline, and the adjoining areas of influence are easily arranged to overlap in such a way as to produce an even action all over. The face presents full in front, the lips, which need no treatment, and must be exposed to no risk; while the nose, which is in similar case, is so prominent, that if the face were treated in the same way as the scalp, its proximity to the X-ray tube would expose it to excessively strong action. The chin again is prominent, but needs treatment, and so must not be protected from the X-rays altogether, but it must be saved from the excessive influence which would be the natural result of its prominence. Thus the problem is to give different degrees of treatment to parts which are close together and on the same level, and to give equal treatment to parts which are close together but on different levels.

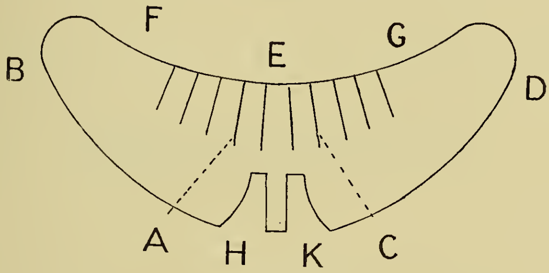

FIG. 45.

"The method which I have adopted, and found to be very successful, is as follows:—

"For the protection of the lips a piece of tin-lead foil is cut out, of such a size and shape as just to cover the mucous membrane, while leaving the adjoining skin unprotected.

"For the nose a piece of foil is cut of the shape shown in the diagram, the various parts being proportioned to suit the individual patient. The edge A, C, is placed along the line between upper lip and nose, with the openings H, K, opposite the nasal orifices. The sheet is bent at the dotted lines A, C, so that the wings AF, CG, cover the sides of the nose. Then the narrow tongues between the slits at E are neatly bent over the tip of the nose and over one another, and F, G, are secured in position by a small strip of adhesive plaster which sticks to the bridge of the nose and to the wings of foil on its sides. When an area of activity has its centre so near the back of the cheek that the effective rays would act upon the hair just above and in front of the ear, this hair must be protected by a piece of lead-foil.

"The next thing to be determined is where to fix the centres of action—that is, the spot where the rays are to fall normally or perpendicularly from the focus of the tube. These centres should be at a distance of about 4 inches apart, so that in the region between two centres the oblique rays acting from two more distant foci may combine to produce an effect equal to that of the perpendicular rays in the centre of each area coming from one focus which is nearer. The fixing of the centre will depend partly on the shape and size of the patient's various features—depth of upper lip and chin, breadth of chin, &c.—and partly on the width to which the part of the growth which is strong enough to require treatment spreads over each feature.

"Thus we may place the centre of one area over the middle of the lower lip, of another beneath the middle of the chin, while two side areas would be centred over the angles of the jaws, or, if the vertical spread of the growth is greater than its extent laterally, one centre may be above and one beneath the ramus of each jaw, the operator trusting for his effect in the middle line in front to the combined action of the two side centres. Again, two centres above the rami may be combined into one beneath the middle of the chin; or other arrangements may suit the conditions of other cases.

"The dose to be given, if possible, is one which will remove the hair, without producing a dermatitis, to give which is a task rendered all the more difficult by the unevenness and irregularity of the surface. In general a full Sabouraud dose is the right application the first time, but measured rather on the light side than on the heavy; for, in my experience, sores are more readily produced on the face than on the scalp.

"Supposing the hair to have been removed without a troublesome dermatitis, the treatment, so far from being finished, is only begun. If left to itself, the hair would soon return. And if a dose be given strong enough to make sure of no return, unadvisably severe sores, with grave permanent injury, will result. The course to be followed is to administer, after the lapse of a month, when the skin is quite sound, another dose of X-rays. This is to be given with as great care as before, and of a rather less degree of severity, since the skin, after its previous treatment, is more delicate than at first. The treatment is again repeated after another month, and so on, up to five or six times, when the epilation appears, so far as evidence up to the present can show, to be permanent."

The older method, that of electrolysis, may be thus described: some form of galvanic battery or constant current is essential, a few dry cells will suffice—three or four new cells are plenty—and a delicate milliamperemeter reading from 1 to 5 milliamperes. The conducting cords should be light and flexible. The positive pole is attached to a carbon electrode placed in a bowl of water, or to an ordinary flat metal electrode covered with flannel soaked in a solution of salt and water; the negative electrode to any ordinary needle-holder, without any arrangement in it whereby the current may be made and broken. It is well to have several needle-holders varying in length from 2½ to 4½ inches.

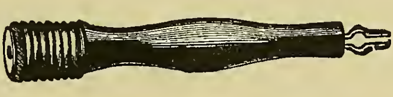

Fig. 46.

A large amount of the measure of success depends upon the needle. The material of which it is made matters not. The shape is the all-important part. When we consider that the nature of this little operation is the carrying of the needle by the side of the hair down into the follicle until it reaches the bottom, it is clear that if a sharp-pointed needle is used, in most cases the point would pierce the follicle walls, whereas if a bulb-pointed needle is used, the operator can feel when the end of the follicle is reached. There should be several sizes of these bulb-pointed needles at hand, to correspond in some measure to the size of the hair and corresponding follicle. The largest size needle that will enter the follicle is the best one to use; a steel needle is quite as good for the purpose as one made of iridio-platinum, platinum, gold, or silver. A pair of epilation forceps is needed. These should have well-ground and well-fitting teeth, so that the finest hair may be securely held by them. Lastly, a magnifying glass is almost an essential. True, the stereoscopic effect of both eyes is lost, but the size of the mouth of the follicle is usually so small that some amount of magnifying is essential in order to enable the operator to find it. Personally I have found a watchmaker's eyeglass the most convenient to use.

All the apparatus being ready and the polarity carefully tested, the part to be treated being cleansed and the needle sterilized, the patient is placed in a chair with the head resting comfortably on a support, and a good strong light so shining on the patient's face that the operator can see clearly the opening of the hair follicle. Where these are not very apparent it has been recommended to rub the area over with a little lampblack and oil, so that the mouth of the follicles may stand out more clearly. This may be made by allowing the flame of a candle to come in close contact with a saucer. Lampblack will soon be deposited, add to this a drop of sweet oil, and make a mixture. With the tip of the finger rub this thoroughly into the area to be operated upon, and gently remove all that can be removed with cotton wool. It will now be seen that each hair follicle is filled with black, and has the appearance of an ordinary comedone. A certain amount of eye-strain is saved, and also it lessens the pain and scarring, since the oil acts as an insulator at the mouth of the follicle, where the cutaneous nerves are, and yet does not interfere with the electrolytic destruction of the root of the hair. The positive pad is placed near the hand of the patient, who is instructed to press it when told to do so, and gradually glide the hand to it until told that sufficient contact has been made or until there is pain when the needle is inserted. The needle is then gently introduced by the side of the hair and follows its direction. Presently a slight check will be felt, which signifies that the bulb of the needle has reached the end of the sheath. The patient should then be told to make the contact, and when sufficient current is passing a few bubbles of froth will appear at the follicle mouth. When this froth has appeared from twenty to thirty seconds, very slight traction may be made on the hair, which will, if the root be destroyed, come away without the slightest force being used and without any jerk. Should, however, it not come away, the current should flow for another twenty to thirty seconds, when the hair will readily come away; often it will come attached to the needle when that is withdrawn, without the forceps being used at all.

In some cases, fortunately few, the hair remains firmly fixed. This may be due to lack of dexterity on part of the operator, or a large root sheath blocking the entrance to the follicle, or when the direction of the hair is abnormal; if when this occurs so much current has been passed that more might leave a visible scar, it is better to use the epilation forceps to remove the hair, although it will probably return, when it may be removed comparatively easily by a second application of electrolysis. The number of hairs which may be removed at one sitting varies considerably, depending to a great extent upon the personal equation, but it is inadvisable to continue the sitting beyond thirty minutes. The work is very trying to both patient and operator, and is apt not to be so satisfactory when the sitting is prolonged. When the requisite number has been removed, freshly-made zinc ointment should be freely smeared on the parts which have been treated. Minute scales will appear wherever the needle was inserted, and the patient should be instructed to let these alone and use the ointment nightly. In the course of a few days there will be no obvious trace of the lesion. Patients will usually ask about the percentage of returns, and there is sure to be some return, for when the hair papilla has not been reached, a hair will surely grow again. It is best to give a conservative answer, and I find that ten per cent. usually satisfies the patient, and that the percentage of returns will be well below this. These "returns" occur in about three to six weeks, and their removal is rendered easier as the tissues with which they are surrounded are less dense than the original tissues.

The importance of removing superfluous hair reaches beyond that of its cosmetic effect. The strain on the nervous system in many cases of this disfigurement renders the duty of the physician imperative in advising its removal.

It may be said that it is beneath the dignity of the doctor to cure acne, to remove superfluous hair, or a mole from the face, but when these troubles are weighing on the patient's mind, and causing much mental suffering, it is surely as worthy a way in which time can be spent as can well be imagined. The fact that warts and moles have a tendency to develop into superficial epithelial cancer is surely a good and sufficient reason for their removal. This tendency is very much more marked when these moles or warts are on the face than on the less exposed portions of the body, since they are subject to more irritation, *inter alia*, by the ordinary ablutions; then dust and dirt easily get deposited, which it is admitted are potent factors in the causation of cancer. It is so easy now for these growths to be removed. The word operation has in the past frightened people so that they preferred to run the risk, but in these days of electrolysis, CO_2, fulguration, &c., this excuse is taken away.

Keloid.—The prognosis is so unfavourable after operative removal, inasmuch as recurrences so frequently take place, that it is satisfactory that in X-rays we have an agent which yields good results in the treatment of this lesion. Under X-rays the keloid will, in most cases, get pale and smaller in size, and in the most favourable circumstances will disappear altogether. The exposure to the rays may have to be persisted in over a considerable period of time.

Pruritus Vulvæ; Pruritus Ani.—When these distressing disorders are truly due to a functional defect of innervation, and not to any organic cause, much relief from the intolerable itching may be afforded by electro-therapeutic measures. Sometimes one remedy and sometimes another would appear to be the most useful, but I have seen much success follow the static brush discharge, the high candle-power lamp, and the exhibition of X-rays, and it is difficult to say which of these three is going to suit any individual case. Relief usually follows from the first application where it is going to do good, and it is useless persevering with the one remedy unless this relief occurs. Sometimes a combination of remedies is very efficacious, such as the static brush following an exhibition of the high candle-power lamp.

Psoriasis.—X-rays give remarkably good results in this disease as far as any one attack or patch is concerned, but in the majority of cases the disease recurs sooner or later. X-rays also will limit the extent and severity of the trouble, and undoubtedly form a valuable addition to a very inadequate therapeutic armamentarium with which to combat this particular skin affection.

Rodent Ulcer, or, as it is usually called in the United States, Superficial Cancer, is fortunately very amenable to electro-therapeutic measures. The selection of the particular remedy depends upon the nature of the case and the surrounding circumstances. The treatment of this disease by X-ray, Zinc Mercury Cataphoresis (or Ionization), and by Fulguration and by Diathermy, is discussed in the chapter on Carcinoma and Sarcoma, and it is impossible to say which of these particular remedies produces the best results. Recently the application of solid CO_2 has been used with a considerable amount of success, but all of these remedies are useful. X-rays perhaps should be tried first, since their application is painless, and the treatment occupies but little time and the patient suffers no inconvenience.

Tinea.—The treatment of this disease by X-rays, being carried on daily at all of the hospitals, calls for little comment. The following note by my friend, Dr. Wm. Hampson, gives the technique which proved very satisfactory in his hands:—

"Epilation of the scalp for ringworm is now so well established as a routine hospital proceeding that it is no longer necessary, in a practical work, to give the reasons for adopting it, or to meet those which have been urged against it. All that we need do, in a practical treatise, is to indicate the proper occasions and the most effectual method of its employment.

"First, then, as to the proper scope of the treatment in each case. A very common event in the X-ray department of a hospital is the appearance of a mother bringing her little girl, whose head has been condemned by the "skin doctor" to "go under" the X-rays. The head is covered with luxuriant locks of curling golden hair, of which mother and child are equally proud. But a comparatively small patch of ringworm has been noticed, and the mother fondly hopes that by taking this in good time she is going to save practically all the other admired tresses. If the operator, yielding to her importunities, allows that small patch alone to be treated, he almost certainly lays up repentance for himself and for the mother. When the child returns, a month later, with the small treated portion nicely cured, the mother has already noticed a number of other spots around it, where the disease is breaking out, and careful examination makes it evident that the whole scalp must be epilated. The previous month's treatment has been entirely thrown away. In the few cases which turn up among well-to-do people in private practice, the disease has been noticed early, and its spread has been carefully guarded against by the use of antiseptic ointments. If, therefore, a careful examination shows no other than the patch already detected, this may be treated alone, with good hope that its cure will entirely remove the disease. But in hospital practice such a partial epilation should never be undertaken until the hair has been cut short for a space of at least 1½ inches all round the affected area, so as to permit of a really clear observation of the state of the scalp—a thing which is impossible while the hair is long.

"If the patch to be treated does not exceed 4 inches in diameter, and is not too convex for fairly equal action all over, it may be treated as one area, at one exposure; if larger, it will require two, three, or more exposures over adjoining areas.

"If the whole head has to be done, as is usually the case in hospital work, the treatment will require five or six separate exposures, according to the size of the head and the extent to which the action has to reach towards the very edge of the scalp.

"In either case one of the centres of action will be the vertex, a point chosen, as nearly as may be, at equal distances from all points in the periphery; and another the frontal, straight before the vertical, and at a distance from it of 4 to 5 inches, which will bring it within about 1½ inches from the edge of the scalp over the forehead. In the case of five areas the third will be the occipital, diametrically opposite to the frontal, and the two others will be at the sides; so that there are four centres, at equal distances circumferentially, and each about 1½ inches from the edge. If the head be a very large one, and the extreme edges of the scalp require treatment, it is better to avoid the risk of getting unepilated patches, and much trouble and the devotion of another month's time to supplementary treatment, by dividing the scalp into six areas at first. The vertical and frontal remain as before; but there are two occipital, one at each side, about 4 inches apart, and the two at the side are pushed a little farther forward; the whole five, like the four under the previous arrangement, being equi-distant circumferentially. The object is to obtain equal action all over the scalp; and it might seem at first that this will not be attained, because at each centre of action the rays act at a shorter distance, and in a perpendicular direction (and therefore act more strongly), than in the intervening spaces, where their source of origin is farther off, and their direction is more oblique, so that they have more skin substance to pass through before reaching the roots of the hairs. The greater distance and the greater obliquity both weaken the action of the rays in the intervening spaces; but complete compensation for this results from the fact that in these intervening spaces the actions from several adjoining centres reinforce one another, the result of this overlapping effect being that the total action in any of these areas is equal to that in the centres themselves.

"*Position of Patient and Tube.*—The child should in all cases be lying down, with the head resting on some support, such as a sand cushion, which is not so hard as to irritate, but is firm enough to yield no further when once impressed to the shape of the head resting upon it. The patient should not be treated in a sitting position, with a nurse steadying the head; both because of the danger to the nurse from repeated exposures, and because the head, even of a willing and well-disposed child, cannot be guaranteed against change of position from fatigue and restlessness, while in the case of a rebellious patient such an arrangement gives away every advantage in the long and trying conflict to the rebel.

"The head, having been irradiated, is to be frequently washed and treated with antiseptic ointment until the hair has fallen out, when the disease will be eradicated.

"The distance employed, or at any rate aimed at, by most operators, between the focus of the X-ray tube and the area undergoing irradiation is 15 centimetres. Upon this depends the Sabouraud method of estimating the strength of the X-ray dose, which accordingly will next be described.

"The ordinary viewing-screen employed by radiographers consists of platino-cyanide of barium, a material which is made to fluoresce by the X-rays. They have a further influence upon it, causing it to change colour. It passes from its original greenish colour through yellow to brown of varying degrees of intensity, according to the amount of X-rays received, which again depends upon the activity and proximity of their source and the length of the exposure. Thus the amount of the change in colour is a practical measure of the strength of the action; and accordingly small discs of this material, known as Sabouraud-Noiré pastilles, if exposed to the action of the X-rays at the same time as a patient, are a useful measure of the dose he receives. There are various difficulties, the chief of which is the small extent of the colour-change and the great delicacy therefore required in observation. This is partly overcome by placing the test pastille only half as far from the focus as the patient. The action upon it is consequently four times as great, and so much easier to observe correctly. Several other difficulties remain. The change of colour in the pastille is to be compared with the standard test-piece by daylight. Now daylight has the property of restoring the pastilles to their original colour, or nearly so, not instantaneously, but promptly enough to make it necessary to lose no time over the comparison, at the risk of having it falsified. In the case of doubtful and anxious performances this is a serious disadvantage. Again, the apparatus for holding the pastille at its half-distance from the skin is seldom adequate. The stem is springy, or not firmly fastened, or it is fixed where the glass of the tube is extra thick, and hinders the rays from developing the same activity as those which are acting on the patient. Where the pastille-holder is fixed by construction as a part of the tube shield, it is seldom at the right distance from the focus. Such shields are often made to accommodate tubes of 15 cm. at least. The radius of such a tube is 7½ cm. Two more cm. must be allowed to prevent the pastille from being browned by the mere heat of a tube wall in its close proximity; so that the pastille is placed at a distance of 9½ or 10 cm. from the focus. This would require that the patient should be 19 or 20 cm. from the focus, if the Sabouraud measurement is to be faithfully employed and with trustworthy results. But at 20 cm. from the focus the action on the patient would be so intolerably slow that operators in a hospital cannot find time to work on such a system, and the head is, in practice, placed at about Sabouraud's regulation distance, 15 cm., though the pastille cannot be placed at the half-distance, 7½ cm. This introduces the need for much guess-work in the measurement. Another trouble depends on the fact that Sabouraud's test tint is arranged for comparison with the pastille by daylight. In this country, at the times and places where the X-ray operator has to be hard at work, daylight is often playing truant, and this makes more guess-work necessary. There is also some risk and anxiety in connection with the repeated use of Sabouraud's pastilles after they have had their brown coloration brought back to green by exposure to daylight, since, on the one hand, the greatest possible restoration may not have yet taken place, and, on the other, the greatest possible is never complete restoration; as Dr. Howard Pirie has remarked, a pastille once exposed to the X-rays never quite returns to its original tint. In spite of these draw-backs, Sabouraud's system of dose-measurement can be worked with great advantage, and has rendered it possible in the last few years to do a great deal of work in hospitals, which without it would have been made impossible by the risk of giving a wrong dosage; for the other methods of measurement, though some of them are very useful for refined scientific researches, are for the most part too cumbersome for large quantities of work which has to be done against time.

"To overcome some of the difficulties of measuring the dosage by Sabouraud's method, and to extend its usefulness, the present writer has introduced some modifications of method, and a more delicate instrument. A given degree of colour-change in the pastile shows, under an incandescent electric light, at least twice as strongly as by daylight; the browning is much easier to see, and so the judgment can be twice as delicate. All the observations, therefore, are made by this light, a carbon filament lamp being chosen so as to give every one the same tint. This carries with it the added advantage that work can go on by night or in foggy weather, when there is no daylight to make the comparison by. The

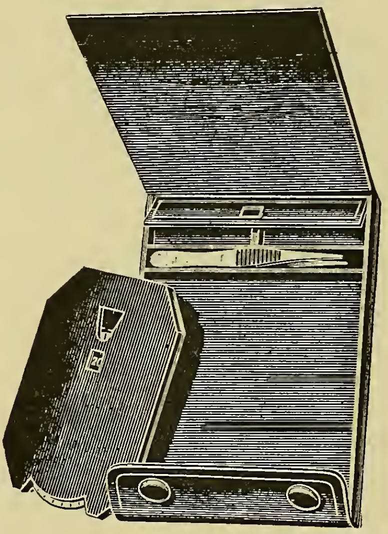

Fig. 47.
Röntgen Radiometer.

new instrument exhibits twenty-five degrees of colour, instead of Sabouraud's two. Of these any four complete successive grades, if produced on a pastille at the same distance as the patient's skin, as, for instance, on a protected part of the skin close beside the desired field of action, indicate the completion of a Sabouraud dose. If, therefore, the pastille be exposed at half skin-distance, the completion of a dose on the skin is shown by sixteen stages on the new radiometer, so that it becomes possible to give a half or quarter dose without guessing, and the whole dose with much greater certainty and exactness. Delicacy of observation is assisted by shading the eyes from the test light while the radiometer and pastille are well exposed to it, and by mounting the comparison discs on a black background. They are easily turned on the circumference of a small revolving card, so as to bring each one separately into close juxtaposition with the pastille to be examined. Since four grades at skin distance measure one Sabouraud dose, it does not matter which grade we begin with, and there need be no anxiety as to how near the pastille has come back towards its original tint.

"Working with the pastille at skin-distance gets rid of the anxiety about placing it with certainty at half-distance. The greatest advantage of the system is the shortening of time by permitting action at a shorter distance. We see that if the tube be 15 cm., with a radius of 7½ cm., the child's head must be 19 cm. from the focus to allow of Sabouraud's measurement being applied correctly, and the action at this distance will be very slow. With the pastille at skin distance, the head may easily be brought up to within 10·6 cm. of the focus, at which distance the action of the X-rays, by the principle of inverse squares, becomes twice as strong as at Sabouraud's 15 cm., and the time required is only half as long. This, in the execution of large quantities of hospital work, is a very great gain."

Warts, Moles, and Nævi.—The treatment of these is so much the same that they are here classed together. Where the growth, usually a mole (fibroma) is associated with hairs these hairs should be removed by electrolysis in the manner above described, after which it should be treated in the same manner as a wart-like mole (*nævus verrucosus*), or the wart (papilloma) itself. For vascular nævi much may be done with electrolysis, but the more modern method is to treat this affection with CO_2, X-rays, or radium.

The fibromatous or papillomatous growths of a small area and raised above the skin are eminently suited for removal by electrolysis. A sharp-pointed straight needle is thrust through the base of the growth and connected with the negative pole of a galvanic battery, the positive being attached to any indifferent dispersive electrode; a current is allowed to pass until a good deal of froth appears, and the needle works about loosely in the passage it has made. The current is now turned slowly off, and the base of the growth is transfixed at right angles to the first puncture, and the current turned on as before. This manœuvre should be repeated at least twice more (except in the case of minute growths), when the tissue comprising the base of the growth will be practically destroyed, at all events so much of its nutrient supply will have been cut off that the wart or moles will shrink up, dry, and drop off. It may be that at the first sitting all of this nutrient supply may not have been destroyed, in which case the treatment can be repeated. It is better to do too little than too much, for in the latter case a slight depression in the surface of the skin may be left. Electrolysis forms a most satisfactory and easy method of dealing with these unsightly blemishes.

There are other diseases of the skin in which electricity may be employed advantageously, but in those above mentioned it has chiefly been hitherto used.

CHAPTER XXI

ELECTRICITY IN RHEUMATISM AND STIFFENED JOINTS

With acute rheumatism (rheumatic fever) electricity has rarely an opportunity to be exhibited, so what the results would be I cannot say, but arguing from analogy, could this agent be brought to the bedside of the patient it would probably give considerable relief from the pain.

The treatment of muscular rheumatism has been discussed in the chapter on lumbago. Here the treatment described is that which is useful in rheumatoid arthritis, and in most cases of chronic articular rheumatism. The following articles were first written for, and published in, Mr. A. H. Tubby's recent work, and it is by his kind permission that I reproduce them here.[1]

Rheumatoid Arthritis.—No apology is needed for any suggestion that can be made in this malady, which is still classed by many as an incurable disease. It is a fact familiar to many workers in the field of electro-therapy that most of these cases can be relieved, and the course of the disease be arrested by one or other of the different forms of electricity. Atrophic arthritis is associated with malnutrition and faulty metabolism, while the rationale of most forms of electric currents is that they improve nutrition and conduce to healthy metabolism. Before the joints are affected, there is a stage, more or less prolonged, during which obscure and profound malnutritional changes are taking place. It is possible for the disease to be treated before the joints are affected; I believe that the secondary effect can be prevented. As a rule, it is the pain in the joint which leads the patient to seek advice, and it is primarily due to stasis and congestive infiltration. The application of electricity is of great benefit in this stage and whilst alterations are taking place in the softer structures. When the peri-articular and synovial tissues are undergoing thickening, the static wave current, surging through them, relieves congestion and lessens the thickening. Even later on, when the atrophic stage is reached, the minute vibratory action of this current improves the nutrition of the parts, retards and arrests the disease.

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[1] *Deformities, including Diseases of the Bones and Joints.* Second Edition. Macmillan & Co.

In using static currents it is essential to have a sufficiently powerful machine. Much of the adverse criticism to which static electricity has been subjected may be traced to the fact that many workers have used, and are using, insufficient and feeble machines. The technique of the application of the static wave current has already been described (pp. 40 *et seq.*). The static machine should be capable of a 10-inch spark-gap, when the metal electrode is at least 150 to 200 square centimetres in area. Whilst the current is passing, tissue-contraction is induced, and the muscles can be seen pulsating. All the soft tissues are thus affected, so that it is not difficult to understand why the current should cause diminution in the quantity of fluids in the infiltrated area, and lessen or relieve the stasis upon which the arthritic condition depends. It is probable that healthy cell action is thus induced and lively physiological activity replaces pathological torpor.

The static indirect spark (very different in its action, be it noted, from the high frequency sparks) acts in a similar but more energetic manner. Here the negative side of the static machine is connected with the insulated platform by means of a brass rod, and the sliding rods are widely separated. The static machine is then started, and sparks are taken from the patient's body by means of a brass ball attached to another grounding. The spark should be from 4 to 8 inches in length.

There is also the static brush discharge, which is useful in rheumatoid arthritis, more especially when the pain is very acute. Here the connections are as for the indirect spark, but the brass ball is replaced by a stick of white wood which must not be too dry. This is brought near the affected joint, and a blue light is seen passing between the joint and the wooden stick. In appearance it is like the high frequency effleuve, and the patient experiences no unpleasant sensation, merely feeling a breeze about the parts.

There are other forms of electricity besides those derived from the static machine which may be used with advantage in arthritis deformans, and chief among them I would mention electric light. A single lamp of high-candle power is most useful, especially as a prelude to the administration of static electricity. Professor Bier[1] remarks, "In chronic articular rheumatism, in arthritis deformans, in acute rheumatism, active hyperæmia induced by hot air is principally indicated." By the use of the high candle-power incandescent light we obtain an active hyperæmia, and I have found it to be superior to that produced by heat without light, not only in giving immediate subjective relief, but the effects also appear to be more lasting. Why this should be so is difficult to say, unless it is directly due to cell stimulation from actinic effect. The light it has been my habit to use is an ordinary incandescent lamp of 500 candle-power, surrounded by a bright metal reflecting hood. This is slowly swayed to and fro over the affected joint or joints for twenty minutes to half an hour, holding it as near to the patient as the heat will permit. At the end of this time the skin is somewhat reddened, and the pain is, as a rule, much less. The improvement will be prolonged if the application of the electric light is immediately followed by either the static wave current or by the static spark.

Another measure which is sometimes of use is Ionic Medication by means of the galvanic current. It is especially indicated where there is a boggy swelling around the joint. The technique is as follows:—Make a 2 per cent. solution of sodium chloride in sterile water. The joint may be immersed in this, or wrapped round with some twenty thicknesses of absorbent lint, which has been saturated with the solution. A piece of tin-foil is then firmly bound on to the lint, covered with oil-silk, and connected with a wire to the negative side of the battery. If the limb is immersed in the salt solution, a wire leads from the solution to the pole. Everything should be firmly attached, the bandage secure, and close contact made at all metallic junctions. This is the active electrode. The indifferent electrode may be placed anywhere upon the patient's body, but it should have a larger superficial area than the active or negative electrode; it may be similarly made and wrapped round the leg, or a hand or foot or leg may be immersed in water; connection is made with the positive pole, and again all contacts should be examined and made perfect. Everything now being in readiness, the milliampere meter and rheostat being in circuit, the current is turned on. The rheostat is gently, slowly, and evenly moved, and the current flows, the amount passing being carefully noted on the meter. The importance of increasing the current slowly and evenly cannot be overestimated. In estimating the dosage in any one sitting, the sensations of the patient are the best guide. Theoretically, it should not exceed one milliampere to the square centimetre; but, practically, the current strength is only limited by the patient's toleration, which is usually very much less than this. The treatment ought to be painless, and when discomfort is felt, the rheostat is turned gently and slowly back to that point at which the patient says he is comfortable.

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[1] Bier's *Text-Book of Hyperæmia*. London: Rebman, 1909, p. 396.

The current registered by the meter will naturally vary in direct proportion to the size of the electrode. To give a general idea, however, if the fingers of both hands are covered by the electrode, the current, cautiously increased, will usually be well borne up to 30 to 40 milliamperes. Larger areas will, of course, allow larger current, and cases are recorded of patients who, after the first twelve minutes, could tolerate 100 milliamperes without pain.

The treatment lasts about thirty minutes, and is continued thrice weekly, the frequency of the applications decreasing *pari passu* with the improvement brought about. In successful cases from the first, the patient observes increasing freedom of movement, lessening of the stiffness of the joint, and in many of the painful varieties of arthritis, a diminution of the pain. The chlorine ions are thus forced through the skin and into the sclerosed tissue. Ankylosis is relieved by bringing about resolution, and the joint regains its freedom of movement. Dr. A. Caries presented an exhaustive study of this current in arthritis in his Bordeaux Thesis, January 1905.

Yet another electro-therapeutic measure which has given great relief both in rheumatoid arthritis and tuberculous arthritis is the application of X-rays. In the hands of some physicians very excellent results have been obtained. Great care is required not to burn the patient, as maximum doses have to be administered. This risk is avoided by filtering the rays and excluding the soft rays.

The use of electricity in joint affections is no new thing. Among the first observers to use electricity in the treatment of joints was R. Remak, 1856. Later Danion (*Traitement des Affections articulaires par l'électricité.* Paris, 1887, p. 338) was successful with this therapeutic measure. Leduc, in *Arch. d'électricité médicale,* 1894, p. 478, and in subsequent writings, describes in scientific detail his personal success in the treatment of arthritis by electricity. C. Leo V. Marino, M.D., *Australasian Medical Gazette,* July 1890, reports several cases of arthritis treated by electricity, and says: "In subacute and chronic cases, whether of rheumatism or arthritis deformans, in stiffness of the joints following sprains, dislocations, or fracture of the joints, in periarthritic swellings, and the like, electricity stands unrivalled." Dr. G. W. Gwyer, in an article on the treatment of fibrous ankylosis in the *Annals of Surgery,* August 1893, gives an account of the use of the galvanic current in the treatment of several cases. The pain was immediately relieved, the range of motion increased, and part of the fibrous tissue absorbed.

It is impossible to lay down general rules for treatment in any particular case. Each case may differ in cause, in general health, or in the degree of the local affection. All of them must receive careful consideration and individual treatment.

Treatment by Ionization of Chronic Stiffness of Joints.—In all incomplete ankylosis there exists one common factor, either causative or concomitant, and that is a fibro-sclerosis. It may be that all the stiffness is due to this sclerosis, in which case it can be lessened and even removed by ionization in proportion as the fibroid process enters into the pathology. A skiagram should aid the prognosis considerably.

These short notes confine themselves to those cases of stiffness, of more or less long standing, which are due to the existence of sclerosis or cicatricial tissue. In ionic medication we have a remedy which has the power of resolving this tissue. Seventeen years ago Professor Stephane Leduc suggested this method, and it has been gradually gaining ground ever since. It is simple and well within the reach of every medical man. All that is required is an ordinary galvanic battery (the cells should be of large size, so that the internal resistance may be as low as possible; there should be twenty to thirty of them connected in series, having in all a potential of thirty to forty volts), a rheostat whereby the current can be gently and steadily graduated or regulated, a milliampere meter to measure the current, connecting cords, absorbent lint, and pieces of some pliable metal, such as sheet tin or metal composition of an alloy of lead and tin, some common salt and sterile water.

The theory of ionic medication is too complicated to discuss here. In brief, we know that when a constant current is passed through a salt in solution, the constituents of that salt are set free, and they travel, or have a tendency to travel, from one pole to the other, hence Faraday called them "ions" or travellers. That the introduction of these ions is possible is easily proved by using strychnine or cyanide of potassium on a rabbit, when the animal in the former case will be seized with ordinary strychnine convulsions, and in the latter will die instantly. Again, if iodine be administered by ionic medication and the part afterwards opened, the characteristic reaction may be obtained in the tissues beneath the surface.

Certain constituents are set free at the negative pole and others at the positive pole. Speaking generally, the ions of metals are liberated at the positive pole, and the ions of non-metals at the negative pole. Thus chloride of sodium in solution is split up, the ions of chlorine going towards the positive pole, and the ions of the metal sodium towards the negative. The chlorine ions have the property of resolving the fibrous tissue which is causing the ankylosis. It is upon this sclerolytic property that the ionic treatment of ankylosed joints depends.

The technique has been described on page 174. The treatment should last about thirty minutes, and be continued thrice weekly, the frequency decreasing *pari passu* with the improvement in the patient to twice weekly, and then once a week. Improvement may be noted from the beginning, the patient will observe the increased freedom of movement, a more general feeling of flexibility, and in many of the painful varieties of arthritis a diminution of the pain. It cannot be claimed, however, that this happy result invariably follows ionic medication.

One practical point may be noticed. It sometimes happens that, as soon as the current is turned on, the patient will complain immediately of a stinging pain. This will be found due to some skin abrasion, such as a scratch; the current should be turned off, the electrode removed, and the lesion should be covered with a drop of collodion, when the treatment may be resumed in comfort. Another point is that rings should be taken off. A patient I was treating for a stiffened right hand, to which I was applying chlorine ions, had placed the left hand in plain sterile water, in which was a carbon terminal, acting as the indifferent electrode, after receiving a current of 25 ma. for thirty minutes a burn developed under the wedding-ring, which healed up with difficulty. It may be mentioned that not only on joints can this method be used, but also in ophthalmic troubles where this fibro-sclerotic tissue exists, such as rheumatic scleritis and periscleritis, and in other diseases such as pleurisy, where the pain depends upon adhesion; in fact, wherever we know that the pathological condition is caused by or accompanied with fibrous tissue, the electric sclerolysis with the ions of chlorine may be used with advantage. I append a brief résumé of five cases, the first three reported by Prof. Leduc, and the last two from my own practice:—

1. A complete ankylosis of the fingers, following an abscess of the hand, in a young soldier who was treated in a military hospital for six months by different methods. As there was no improvement, he was dismissed the army. After two electrolytic séances, with his hand in a bath of a solution of chloride of sodium, which took the place of the kathode, for a period of thirty minutes with a current of thirty milli-

amperes, he recovered the power of movement so completely that no trace of ankylosis remained.

2. A state forester, after six months of immobilization for a phlegmonous arthritis, had his knee completely ankylosed for five months. After two months' treatment, consisting of nine electrolytic séances, each of which lasted forty minutes, with a kathodic compress impregnated with sodium chloride and a current of 100 ma., he could walk perfectly. He was able to resume his duties, which he has continued without interruption ever since. The treatment began with two séances per week, which were subsequently diminished to one per week, and then one every fortnight.

3. A young woman had an ankylosed knee-joint after typhoid fever. It was a very painful variety of chronic arthritis, which had remained unaltered for eighteen months. After twelve electric séances, with a kathode applied to the knee, the pain disappeared, as well as all thickening of the tissues, and the movements became free.

4. Patient was a lady aged fifty-nine years. She complained of a "gouty hand, especially the thumb," which she could not use much. She said the bone seemed sore, and it ached, especially after using it. The trouble had lasted four years, and was getting worse. I administered chlorine ions to the hand complained of, placing the other in a bowl of water as the indifferent electrode; the current strength was 30 ma., and was allowed to flow for thirty minutes, thrice weekly. Improvement was marked from the first, and patient had very little stiffness and no pain at the end of the month.

5. Patient was a lady aged sixty years. She had an attack of "gout" in the right knee three years ago, when she was confined in her bed for one week. Since then any exercise causes pain. There was, on examination, a chronic synovitis, with limitation of movement due to the thickening of the capsule and ligaments. The joint was bound with saturated lint, the foot of the same side was put into a bath, acting as the indifferent electrode, and a current of 35 ma. was administered for thirty minutes. This was repeated for six times, with intervals of three

days, and then the patient left London with no perceptible difficulty in walking, and complaining of no pain.

I am not claiming for this method of treatment that it is the only agent we have, or that there are not other forms of treatment which may be employed with advantage. "It is not the agent . . . but the reaction of living tissues to an agent," upon which we depend for rational and successful treatment. This much may be safely claimed for the ionic method of medication, that it is easily employed, the local trouble has local treatment, it is painless, it has no ill effects, and in many cases marked improvement is early manifest.

In ionic medication it is difficult to estimate the percentage of successful cases, possibly 30 to 40 per cent., but at any rate it places a method of treatment within the reach of any intelligent practitioner, a method of treatment for a troublesome and chronic affection, for which too often the patient is told that nothing can be done.

Mr. Tubby says: "Mechanical measures by adjustable splints, ratchets, and screws, and weight-extension, are valuable adjuncts. The measures which we have just indicated are suitable to limitation of joint movements such as follows fractures and joint injuries, or as is seen in the course of arthritis deformans, and after non-tuberculous inflammation in and around the joint."

CHAPTER XXII

ELECTRICITY IN SOME DISEASES OF THE ALIMENTARY SYSTEM

Dyspepsia.—In some diseases of this system electricity has a great sphere of usefulness. Chief among these are dyspepsia (especially those cases associated with hyperacidity or dilatation), colitis, hæmorrhoids, chronic constipation: of these the first and last are often connected, and frequently I have noticed that while relieving the former, the latter has been cured.

The symptoms of dyspepsia are well known; roughly it may be said that to be conscious of the process of digestion amounts to indigestion, and this may be experienced as any symptom varying from a sense of weight or fullness after eating to severe pain. Before proceeding with any treatment, the diet and habits of the patient should be carefully gone into, and advice given as to the correction of these, if necessary. Two methods of treatment have proved quite successful; one a sharp application of the high candle-power light followed by a treatment by the static wave current, both over the upper part of the abdomen, and the other the application of the sinusoidal current. The light and wave have already been sufficiently described: the sinusoidal is thus administered. Two wet electrodes, measuring about 6 by 4 inches, are placed one on either side of the umbilicus, and there fixed by means of a broad belt; the current is then applied from fifteen to twenty minutes, of a strength adjusted to the toleration of the patient, who should be given a newspaper or book, so that his mind may be occupied, and the time pass more quickly.

Among the therapeutic effects which we hope to secure:—
(1) Strengthening of the abdominal muscles, so helping (*a*) the prolapsed abdominal viscera, and (*b*) decreasing the quantity of blood in the abdominal veins.

(ii) Increasing the abdominal circulation, and hence favouring the excretion of the poisonous intestinal products, and relieving the auto-intoxication. This can be proved by frequent testing for Indican, when it will often be found to be present after the first treatment or two in an increased quantity, and later on to be less evident.

(iii) Relieving the intra-abdominal congestion, and this includes portal congestion, for I have often seen hæmorrhoids relieved by this form of treatment.

(iv) Improving the condition of the stomach and liver, as is often evidenced by the general improvement in the sensitiveness of these organs.

Chronic Constipation.—In conjunction with these forms of treatment where there is evidence of auto-intoxication, the light bath should be advised thrice weekly at first for its eliminant effect, to get rid of the poisons already formed, and later relying upon the treatment to prevent the formation of any more. The use of the light bath is of similar value in the beginning of the treatment of chronic constipation. It is a very well-worn topic to discuss, so well-worn, and so ever present with us, that even as familarity breeds contempt, so does the constantly recurring condition of constipation often fail to receive the attention to which it is entitled. It has been said that nearly half the total number of patients who consult physicians suffer more or less from it, and yet how many are treated for it with a view to its permanent cure?

For a moment let us consider the causes of constipation, and here in the great majority of cases there exists one definite set of pathological changes constituting a cause, by whatever primary condition brought about, viz., a weakness, atony, or paresis of the muscular coats of the intestine, partially paralyzed valves, and a want of tone in the mucous membrane. This set of changes seems to constitute the cause of constipation, whatever the primary conditions, be they local or general, leading up to it may be.

The symptoms of this malady, apart from the obvious negative one, are so insidious that they are apt to be overlooked by the patient and disregarded by the physician. It may indeed happen that even the one negative symptom is absent, and that there may be a daily movement, the condition being that the large bowel up to the hepatic flexure or even to the splenic flexure is constantly or frequently loaded, yet the patient obtains from the overflow a daily movement as well as a daily dose of poison from the loaded bowel. Or again the simple question to a patient as to the regularity of the bowels does not necessitate a scientific reply; a patient the other day who came complaining of a pain in the chest after meals to whom I put the question as to a daily movement, replied confidently, "Oh yes; every day," and so the word "daily" went down in my notes. Later, feeling sure that I had a case of auto-intoxication to deal with, I again pressed the point, when she replied that she was never constipated, and never had been, because she "always took medicine."

The importance of relieving the condition of chronic constipation cannot be overestimated: it may affect the primary digestion (even as it may be caused by it). The constitutional effects may be manifest by headache, lassitude of mind and body, anæmia, and the thousand and one indications of auto-intoxication. Auto-intoxication is the poisoning resulting from the defective elimination from the body of certain products of digestion. The products may be abnormal in character or abnormal in quantity. We all know that normally the food principles that are necessary for the nutrition of the brain and other parts of the body are absorbed from the stomach and intestines, and then carried by the circulation to the various parts of the body, leaving the débris, containing very little nutriment, but much poisonous and effete products, to be passed on and evacuated. When, as in constipation, these products, instead of being passed on, are absorbed into the system, we have arrived at the auto-intoxication or self-poisoning which I think occurs to a greater or less degree in every case of chronic constipation. And when we come to the manifestations of auto-intoxication, we find that there are almost as many varieties as there are names of diseases, and that they vary in each individual at different times. From the lassitude and drowsiness which are apt to follow a full meal, which Sir Lauder Brunton attributes to the absorption in excess of the normal digestive products, and so are a mild manifestation of auto-intoxication; through many of the severe constitutional disturbances associated with gastric disorders in childhood (Heubner) up to the headaches, irritability, insomnia, nervous breakdown and finally insanity itself, we find auto-intoxication slowly, insidiously, but certainly doing its work. The idea that auto-intoxication is a causative factor in mental diseases is one to which more attention is being paid day by day.

We can, as we know, easily produce a temporary insanity by introducing poisons into the system such as ether, chloroform, alcohol, or atropine; and if we can so easily do this, is it any stretch of the imagination to suppose that other poisons formed in our intestinal tract can do the same? It has been calculated that every human being in two days and a half excretes enough poison to kill himself. The effects of chronic constipation being so far-reaching, the importance of relief is of the greatest consequence.

To treat constipation no fixed rule can be laid down; the treatment and advice must vary with each individual case. The conditions leading up to the cause must be ascertained and remedied, but taking as a cause of almost all constipation, as we have already seen, the weakness of the muscles and mucous membrane of the intestine, we can certainly lay down a line of treatment for that, and when the cause is relieved, the constipation is likewise relieved. And one of the best ways to do this is to adopt some of the more advanced lines of treatment, and probably more success has been obtained with electricity than with any other. Electricity will stimulate peristalsis, increase the muscular power of the intestinal coats, stimulate the failing powers of the valves, restore tone to the mucous membrane, help the local and general metabolism, and stimulate the secretion in the alimentary tract. I am not claiming for this agent that it can replace surgery in certain cases, or that in any it should be used alone. The diet should in most cases be re-arranged, and possibly a carefully-drawn diet-list given to the patient.

Habit is another important point to impress upon your patient. The persistence in a habit at a regular period of the day, however futile at the beginning, will, when other methods are being advisedly used, soon become an automatic and successful act. Exercise, regulation of ingested fluids, and perhaps the employment of vibratory stimulation may all have to be called in in order that the treatment may move steadily along to a successful termination.

The three forms of electricity which have been used in the treatment of constipation are the faradic, galvanic, and static.

Of the faradic it is enough to say that it has been shown by the experiments of Schillbach that while the abdominal muscles are strengthened by this current, no effect is produced on the intestinal muscles, and as that is where it is most needed, we need not consider this form of electricity any further.

The galvanic current has been used with some success; the method of its employment being as follows: The rectum is filled with a saline solution, and an anal sound is introduced, thus forming a large cylindrical electrode, a large dispersing pad is placed on the abdomen, then with milliampere meter and rheotome in circuit, the current is turned on and slowly interrupted with the latter. As to polarity, this has to be arranged according to the existing conditions; for instance, if we wish to attract moisture to, or to soften the tissues of, the rectum, then the negative pole would be attached to the anal electrode and the positive to the abdomen, whereas, if we had a bleeding rectum, or wished to drain a congested mucous membrane, or had hæmorrhoids, then the opposite polarity would be indicated.

Personally, I prefer to rely upon the static machine for the current best suited to the treatment of constipation. The current used for this complaint is not painful in its application, and is usually efficacious in its action. The technique is as follows: Let the patient insert Snow's rectal electrode (see p. 50), previously moistened with a little soap and water, and sit on it, then connect it with the positive side of the static machine, ground the negative, and, starting with the spark-gap closed, gradually separate the rods as far as is compatible with the comfort of the patient. This, the static wave current, has the double advantage that it has a constitutional as well as local action. Continue this for about fifteen minutes, and then for the last five minutes gradually close and open the rods, and so produce a surging effect.

In 1902 Dr. Sigismund Cohn stated with regard to this swelling or surging: "By this we understand a current that, starting from zero, gradually swells to a maximum of strength and returns in the same way to zero. By alternately increasing and decreasing the current we produce in the muscles alternations of wavelike contractions and relaxations. The effect of this is tonic exercise of the muscles, and in using it we do not risk the danger of overworking and exhausting them, as their maximum contractions are only of short duration. The circulation of the blood and lymph will certainly be accelerated by this milking-like process, and we can readily understand how the atonic condition of the tissues is improved."

In more obstinate constipation, the static induced current, that is with the Leyden jars in circuit, is used; and the patient is connected to both sides of the machine by means of two electrodes, one in the rectum as before, and the other, a metal pad, over the abdomen; the spark-gap as before, though it will be noticed that the patient will not require so long a one. The treatment should be daily at first, until an effect is produced, and then three times a week until the period of six weeks has expired. During the first week of treatment, especially if the patient has been in the habit of taking cathartics, it may be well to give a triturate of aloin, belladonna, and podophyllin, or gradually-decreasing dozes of any cathartic the patient may have been in the habit of taking. The importance of impressing on the patient a suitable diet, a regular habit, sufficient exercise, &c., I have already mentioned. So by combining the therapeutic, dietetic, and hygienic measures at our disposal we bring the patient through a harmonious treatment to a successful termination.

Auto-intoxication.—Mention has already been made of the use of the light bath for the relief of the auto-intoxication which usually accompanies chronic constipation. It is certainly as speedy a method as there is. An ordinary cabinet capable of giving 1000 c.p. or more should be used for five or more minutes, followed by a cold plunge or douche. The effect is pleasant to the patient, lassitude and depression, consequent upon the auto-intoxication, will be dissipated within a few minutes, elimination rapidly proceeds, while at the same time the liver is stimulated to action, the nervous system is calmed, and both subjectively and objectively the patient is improved.

So with the radiant light to eliminate the toxins, static electricity to stimulate peristalsis and local and general metabolism and secretion in the alimentary tract, alteration in the diet if needed, faults in habit and deficiencies in exercise corrected, there will be few cases of constipation that cannot be relieved.

Colitis is another disorder of the alimentary system in which electricity may be advantageously employed. My friend, Dr. J. Curtis Webb, has so perfected the technique that I wrote to him for a brief description, with which he kindly furnished me, and it is here appended.

"*The treatment is based on the principle of ionization, whereby the passage of a constant current propels the basic ions of any salt in solution from the positive towards the negative pole.* If, therefore, the rectum and colon be filled with a solution of the required salt, and connected to the positive pole of a source of constant current, the negative pole being on the abdomen and back, and a current be passed, there will be a passage of the metallic base of the salt into or through the diseased mucous membrane towards the negative pole.

"The fact has long been recognized that solutions of salts of zinc applied to epithelium-covered surfaces have a particular healing effect in inflammations of these surfaces, and this fact is made use of in the treatment of the above diseases in the following manner:—

"The bowel is first thoroughly washed out in the morning with a copious plain warm water enema, repeated if necessary. It is important to cleanse as far as possible the surface of mucous membrane, and thus give the ions about to be introduced every opportunity of penetrating uniformly. If, however, as is sometimes the case, this procedure either exhausts the patient or causes pain and consequent irritability of the bowel, it must be dispensed with, and all that can be done is to ensure a free evacuation shortly prior to treatment.

"The actual technique of the treatment is as follows: The abdomen is first well soaped and the lather left on. On to the skin are now applied four layers of Gamgee tissue (8 in. × 6 in.) well soaked in a solution of sodium bicarbonate (about a tablespoonful to half a wash-hand basin of warm water). The Gamgee should be laid on very smoothly, layer upon layer, so as to avoid any wrinkles, and on the last layer is placed a sheet of tin or lead (7 in. × 5 in.) connected by a cord to the *negative* pole of the source of current. Soaping the abdomen, using bicarbonate instead of chloride of sodium (the carbonic acid ion being less irritating than the chlorine ion), and the avoidance of wrinkles in the Gamgee, all help in avoiding those troublesome little ulcers which sometimes occur. If there be any acne or other spots on the skin each should be covered with a small piece of sheet rubber or they may be thickly painted over with rubber solution or collodion. When all is in place, cover with a large piece of thin mackintosh sheeting—to avoid wetting the bed or patient's clothes—and then turn the patient on the left side and apply an exactly similar arrangement to the lumbar region. A towel applied as a binder will keep all in place. Both abdominal and dorsal electrodes are to be attached to the *negative* pole, and a useful contrivance to simplify this can be made by any ironmonger by soldering three ordinary screw terminals into a stout strip of copper; the two conducting wires from the electrodes can be attached to two of the terminals, while a few inches of copper wire will join the third to the pole of the source of current. The rectal electrode consists of a spiral of wire attached to a short metallic tube which carries a terminal for the positive wire, and which can also be fixed to the tube from a douche can. Over the wire spiral, which is 12 inches long, is fitted a stout indiarubber tube closed at one end, but with a lateral opening near the point. With the abdominal and dorsal electrodes in position, the patient is now placed on the left side, with a pillow under the buttocks and the shoulders low, and the rectal electrode is passed as far as possible—using soap or any non-greasy lubricant. This electrode is attached to a two-pint douche can, previously filled with a warm solution of sulphate of zinc, 2 per cent., which is hung a little above the level of the patient. About half a pint of the solution should be slowly run into the bowel, and then the current *gradually* turned on till the milliamperemeter registers 15 to 20 milliamperes. The flow of the solution, which continues all the time of the treatment, should be so regulated that there is the minimum discomfort produced, and if the whole two pints can be retained it is an advantage. The current should be allowed to flow for from ten to fifteen minutes, and then *gradually* turned off, the various electrodes disconnected, and the patient permitted to get out of bed to empty the bowel. After the treatment an hour's rest should be enjoined. This procedure should be repeated once every three to seven days, according to the severity of the case and the tolerance of the patient."

Dr. Webb treated fourteen cases—one failure, for which there was a reasonable cause, five so much benefited as to have only the occasional passage of mucus without pain, two lost sight of, but when last seen the symptoms had disappeared, and six were complete and permanent cures.

Dr. Webb first described this treatment in the *Lancet* of Nov. 4, 1905, again in April 22, 1911, in which latter article an improved electrode is described. Other similar results of the same treatment have been reported by another medical man in which the diagnosis of mucous colitis was made by Mr. F. F. Burghard on examination, and in another case by Dr. P. J. Cammidge on a fæcal examination. Also mention should be made of the paper by Mr. F. C. Wallace and Dr. W. Ironside Bruce, read before the Surgical Section of the Royal Society of Medicine on May 12, 1908, entitled "Treatment of Ulcerative Proctitis by Zinc Cataphoresis," in which they report extremely satisfactory results.

Fissure, Rectal Ulcer, and Hæmorrhoids.—Lastly, fissure, rectal ulcer, and hæmorrhoids are conditions which are very amenable to some forms of electrical treatment. For fissure cupric cataphoresis by means of a copper wire laid in the fissure and the current turned on until a greenish stain of oxychloride of copper is deposited along the fissure is often effectual in one treatment, or the static high potential from a glass vacuum tube will often cause the fissure to heal up. In rectal ulcer the same two forms of treatment are successful.

Hæmorrhoids have already been discussed and classified in the chapter on high potential glass vacuum discharge (page 31), and it was there shown how different varieties of piles are affected by that current, and that it had but little effect upon large venous internal piles, or in those with marked hypertrophic changes. These latter may be destroyed under cocaine or hypodermic injection of quinine and urea hydrochloride by the Massey minor monopolar method, which has been already described. In the former, the large venous internal pile, the patients suffer mentally a great deal from the inconvenience they have to undergo when these hæmorrhoids protrude, as they often do, not only after each movement of the bowels, but with the exertion of dancing, or even of walking. Formerly I treated such cases with fulguration, but recently diathermy has yielded much quicker and more satisfactory results. The technique is as follows: The patient comes for treatment, before the bowels have acted, and he has a movement immediately prior to his getting on the operating table, and the hæmorrhoid is not replaced, but allowed to protrude. It is freely cocainized. The patient lies with the large dispersive electrode under him, and the small active electrode is placed on the pile, which may be grasped with a pair of forceps should it show any tendency to recede. The current is slowly turned on, and when the patient feels that it is hot, he is instructed to say so, and the current is instantaneously shut off with the switch, after which the active electrode is removed. It must not be taken away while the current is flowing, otherwise painful sparking will take place. The amount of current reached is about 500 milliamperes. The electrode is applied several times to different situations in the hæmorrhoid, and the patient allowed to go away. I have not met with any pain or inconvenience following the application of this current, and the pile ceases to give any trouble, it gradually atrophies and becomes insignificant. As this treatment is comparatively recent, it cannot be said in what percentage of cases this result will follow, but the few that I have done confirm the truly marvellous results reported by Nagelschmidt. Two cases will exemplify. Mr. R. H., age 50, had suffered from piles since he was sixteen or twenty. For the last eighteen months life had been rendered wretched by them. After each movement they protruded, and patient was often nearly an hour replacing them and getting comfortable again. Three or four treatments with the glass vacuum electrode were productive of little if any effect. Patient was given a diathermy treatment, and told to return in fourteen days for another if needed. Patient returned, saying that up to a few days ago the pile had returned after movement of the bowels, but with diminishing trouble to him. Patient tried to get the pile to protrude, but even after a movement of the bowels was unable to do so, and since then he has had no return of it. He came to me before Christmas 1911, and it is now January 1913.

Another case was that of a lady, Miss M., age 22. She consulted me November 1911, had had hæmorrhoids for several years, with occasional bleeding. Examination showed several acute capillary piles, two external piles, obviously of long standing, and one large internal venous pile, which was causing her a good deal of trouble, as it would come down when she was walking, so that frequently she would have to go into the nearest shop to replace it. Treatment began with the glass tube, which was followed by marked improvement. The capillary piles disappeared. The external piles shrivelled up considerably. The venous pile was smaller, and the bleeding stopped. The venous pile, however, would protrude from time to time, especially when patient danced. Since one application of diathermy it has not come down. The application of this method was very effectual, as the patient bore the current extremely well; twenty-four hours after the application there was a recrudescence of one of the external piles, which patient thought was produced by dancing, but which subsided under Ung. Gall. c̄. Opio. A month or six weeks later there was a slight bleeding, and one small capillary pile appeared. This was relieved with one application of the high potential vacuum current, and an examination failed to find any remains of the large venous hæmorrhoid. Twelve months later patient wrote saying that there had been no further sign or symptom of piles of any kind.

CHAPTER XXIII

ELECTRICITY IN GYNÆCOLOGY

Many diseases of the organs of the female pelvis are peculiarly susceptible to treatment by electricity, for it is comparatively easy to apply the electrodes directly to the lesion, and whether we wish to apply a drug by ionization, or electricity *quâ* electricity, we have usually a readily-accessible part, and good conducting media.

No attempt at a systematic arrangement of gynæcological troubles is here made, rather just those for which the patient usually seeks relief, or rather those in which amelioration can be expected from the use of electro-therapeutic measures.

The question of cancer, and Dr. Massey's book on *Conservative Gynæcology and Electro-Therapeutics* have already been mentioned (Carcinoma and Sarcoma).

One of the most satisfactory results in gynæcological practice has been obtained in uterine fibromata and the hæmorrhages of the menopause by the use of the X-ray.

Elaborate details of this treatment have been worked out by Bordier, Bergonié, Spéder, and others, and the results obtained were usually successful. Bordier uses filters of aluminium, varying from 0·5 millimeters to 3 millimeters in thickness, but the different thicknesses seem to me to be a refinement of detail, which for all practical purposes may be disregarded. Filtration is of the utmost importance in the preservation of the integrity of the skin, but with an aluminium filter of 1 millimeter this may be assured. With a tube of a hardness of about 8 Benoist, such a filter allows about half (50 to 60 per cent.) of the rays to pass through: thus calculation is comparatively easy. The tube used should be at least of this hardness, and I have often used them up to 10 Benoist. The water-cooled Muller tube gives the least trouble. For the purpose of treatment the lower part of the abdomen is divided into three parts, median and right and left ovarian:

each of these areas should be irradiated in turn, the areas not being treated covered either with a lead shield and grounded, or with what is very convenient, a shield made of a mixture of lead and rubber. Each area should get a full Sabouraud dose, 15 centimetres from anticathode, using the filter. Two full doses emitted by the tube will equal one dose on the skin. This dose may conveniently be divided into two or three exposures, thus making a cycle of radiations of six or nine. This cycle should be repeated during each intermenstrual period, and it may take four or five cycles to bring about the desired result.

The class of case which is most suitable for X-rays depends upon the age of the patient, the nature of the fibroma, whether it be interstitial or subperitoneal, freely bleeding or not; as to age, the prognosis is more favourable the more nearly the patient approaches the menopause; when the patient is young, surgery gives the best results. Also it is with interstitial fibroids where there is menorrhagia and metrorrhagia that the best results are obtained with X-rays. Pedunculated fibroids, or where suppurative or inflammatory conditions are concomitant, are not suitable for this method of treatment.

After about the second, or possibly the third, cycle, improvement may be looked for; the hæmorrhages will be less frequent and less copious, and often the tumour will be found to have diminished in size.

In the light of our present knowledge of the X-ray, and with ordinary care and attention to detail, such as the employment of a tube sufficiently high, sufficient intervals between the radiations, proper filtration and accurate dosage and screening, the treatment of duly-selected cases of uterine fibromata should be safe and satisfactory.

The same treatment and remarks apply to the treatment of the hæmorrhages of the climacteric, and to the production of an artificial menopause.

Dysmenorrhœa can usually be benefited by the use of electricity, provided the type be recognized and the appropriate remedy chosen. Where, of course, the condition is constitutional and the cause depends upon anæmia, or a gouty or rheumatic diathesis, its relief by local remedies is unscientific and futile. In those cases where the uterus and appendages are apparently healthy, but where there has been pain from the beginning of menstrual life, and accompanying each successive period, the so-called obstructive type, much may be done. In the case of virgins the high candle-power lamp used daily over the lower part of the abdomen, followed if needed by the static wave current, applied by means of the rectal electrode, passed up the rectum until it rest against the uterus, thrice weekly for about twenty minutes during the intermenstrual period, will be successful in many cases. This procedure is more fully described on page 47. In obstinate cases and in married women the galvanic current may be employed. An ordinary sound insulated, except as to its extremity, which is left bare for 1½ inches, is gently inserted into the cervix, being attached to the negative pole; the positive pole is attached to a large dispersive pad, which is placed upon the patient's abdomen, or under the lumbar region, the patient being in the dorsal position. The current is slowly turned on, and, in the absence of pain, should be allowed to reach 20 milliamperes. This current should flow for about ten minutes, when it should be slowly reduced to zero and the electrodes removed. A simple electrode is made by taking an ordinary uterine sound and passing over it a piece of rubber tubing, or the special electrodes (Fig. 48) made for the purpose may be used. Twice a week is usually sufficient treatment in these conditions.

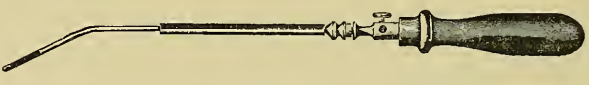
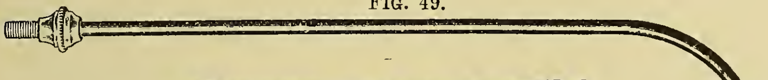


Fig. 48.

It is important not to set up any irritation; hence the current mentioned should not be exceeded, and should any pain be produced, the current should be reduced below that point which is painful. I have often had good results from five-minute applications of 10 milliamperes. What has happened is this: that the electrolytic action of the current has effected a dilatation of the cervix, painlessly and effectually.

Where the dysmenorrhœa appears later in life, possibly after the birth of a first child, it is usually due to some inflammation. The patient is often never quite free from pain, which is aggravated at the menstrual period. In these cases electricity must be used with caution, but it is not contra-indicated. The static high potential vacuum tube (see page 32) is passed into the vagina so that the os rests in the depression at the end of the tube. It is connected with the negative side of the static machine, the positive being grounded. The spark-gap should be cautiously opened until it reaches one inch, and the current, which should be perfectly painless, allowed to flow for twenty minutes. This should be repeated daily until the patient notices relief, when it should be administered thrice weekly. In this type of case where a static machine is not available, the bipolar vaginal electrode (Fig. 49*a*) used with a fine wire faradic coil will sometimes afford much relief, but it should only be persisted in if the pain is relieved from the first. If the pain is made worse, or indeed if it is not made better, it is useless to continue with this current.

Fig. 49.



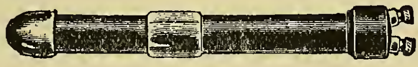


Fig. 49*a*.

Fig. 50.

Should the pain be made worse, it is suggestive of either pus in the one or both tubes, or of such a state of inflammation that surgical interference is probably indicated; and the diagnosis may be further confirmed by passing a monopolar vaginal electrode (Fig. 49) into the posterior fornix, and the dispersive pad on the abdomen, and connecting with the galvanic current. Sometimes a current of 2 to 3 milliamperes will cause the patient pain. When this happens it may be taken for granted that operative measures are necessary, even although nothing can be detected even by the most careful examination.

Leucorrhœa is a symptom of disease rather than a disease itself. The two main diseases which give rise to it which are suitable for electrical treatment are vaginitis and cervical endometritis. In the former where there is usually some passive hyperæmia, the high-potential vacuum current is useful, the discharge losing any unpleasant odour it may have had and becoming less purulent from the first. This current has a beneficial effect upon the whole of the sexual apparatus, relieving congestion and promoting a more healthy condition generally.

Cervical Endometritis.—When, however, the cervical canal is affected and the speculum reveals a viscid opaque excretion coming from the external os so tenacious that it is difficult to remove it with the cotton wool on the end of the probe, then cupro-mercuric cataphoresis should be employed. A copper electrode, or an ordinary sound (denuded of its plating by dipping it in acid), the stem of which is insulated either by coating it in sealing-wax or covering it with a rubber tube, is used as the active electrode. The tip is amalgamated by dipping it rapidly into 40 per cent. of ac. sulph., then into mercury, and then into sterile water. This is connected with the positive pole, and inserted into the cervical canal; the large dispersive pad is attached to the negative pole and placed in position. A current of 20 milliamperes for twenty minutes, repeated two or three times a week, will usually cause the discharge to alter its character to a clear glairy fluid, and eventually to cease altogether. If, at the end of the twenty minutes, the electrode should tend to stick in the cervix, the current, having been turned off, should be reversed and turned on again for a few moments, when the electrode will come easily away. The rationale of this treatment is that a double salt of oxychloride of mercury and copper is deposited within the tissue by cataphoresis or ionization, and there performs its bactericidal work.

Erosion of the Cervix, or granular ulceration of the cervix, is often seen in conjunction with cervical endometritis, and may be allied (pathologically) to it. The treatment is essentially the same: a copper disc on an insulated stem replacing the sound (Fig. 51).

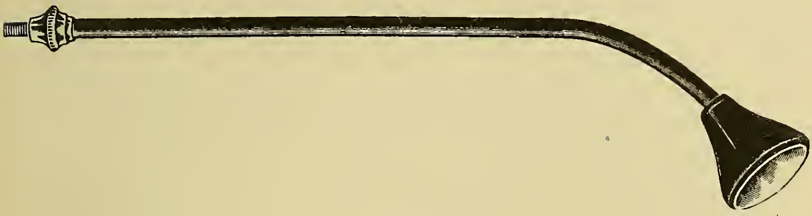


Fig. 51.

Subinvolution of the Uterus—that is, delayed involution of the uterus after pregnancy—is successfully treated by electricity, provided, of course, that it is simple atonic subinvolution and that it is not caused by a laceration or shreds of retained decidua. The current which is most quickly effectual is the static wave administered with a special electrode (Fig. 52).

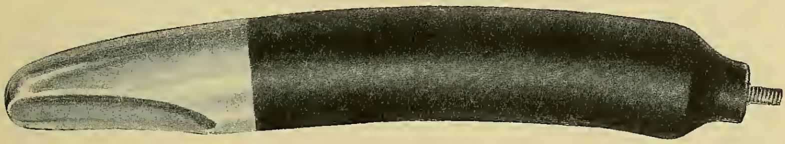


Fig. 52.

In the absence of a static machine, the primary coarse wire of a faradic battery will be useful, one electrode being placed in the posterior fornix and the other on the abdomen. The swelling or surging current gives the best effects.

From either of these currents beneficial effects are quickly noticed, and the flabby, bulky uterus readily improves in tone and decreases in size, while the frequently-present discharge, *pari passu*, gradually disappears.

Sterility is a condition frequently brought to the care of anyone practising electro-therapeutics, and before its cure be undertaken the patient and the patient's husband should have undergone a careful examination, so that all apparent cause for the sterility may have been excluded. There are some apparent causes, such as atrophy or imperfect development in which the use of electricity is distinctly indicated. In these cases, or where no cause can be said to exist, electricity should be tried, and a successful result may be expected to follow in about 40 per cent. of the cases. Where the uterus is smaller than normal, the rhythmic undulatory galvano-faradic current is of much service, one electrode in the posterior fornix, and the other on the abdomen. Where the uterus is of normal size, the vacuum glass electrode may be used alone or alternated with the galvano-faradic current. The treatment should be given for two or three intermenstrual periods, and repeated one year later if unsuccessful.

Vaginismus.—The treatment of this by Static Electricity is highly successful. For the first application a small urethral glass vacuum electrode should be passed into the vagina; when this has relaxed the spasm, and the anæsthetic effect of the current is felt, it may be changed for a small rectal electrode, and so on from day to day until the full-size vaginal electrode is tolerated without discomfort. Metal electrodes and the static wave current are sometimes needed, but the prognosis in all cases is good, presuming, of course, any definite cause, such as a small fissure, or caruncle, is not still remaining as the cause.

Enuresis, while not strictly a gynæcological complaint, may often be relieved by stimulating the spinal centre.. I have found the wave current applied over the lower part of the spine for twenty minutes daily is very effectual. The current should be given daily until a night comes without trouble, when forty-eight hours may elapse between the treatments, which interval may be gradually increased co-incidentally with the improvement reported.

CHAPTER XXIV

MISCELLANEOUS DISEASES

In addition to diseases already mentioned, Electricity can do much good to many others, each one of which deserves a chapter to itself, but this would make the book larger than is intended: hence some of them are grouped together in this chapter: Gout, Spleno-medullary Leukæmia, Goitre, Dupuytren's Contraction, Diabetic Gangrene, Stricture of the Urethra, Spermatorrhœa, Tubercular Glands. I make no apology for grouping together such a heterogeneous collection, the component parts of which have nothing in common, except that they can be relieved by some form or other of electricity.

Gout can usually be favourably influenced by one or other of the forms of electricity. It should be attacked both locally by endeavouring to rid the affected joint and surrounding structures of the bi-urate of sodium deposits and capillary stasis, as well as constitutionally by eliminating the toxic cause, be it uric acid or an alloxur base, and should there be a high arterial tension, this should be judiciously lowered. For the local condition many forms of electricity will relieve the pain: high candle-power light, static brush, static wave, diathermy, and by salicylic acid ionization, or salicylic acid and lithium, combined; which to choose depends a good deal upon the amount of tenderness present. Sometimes the pain is so exquisite that it would be quite impossible to touch the joint with the electrodes needful for the last three modalities. A general light-bath when possible is an excellent prelude to other forms of treatment. The high arterial tension may be dealt with as already described.

Spleno-medullary Leucocythemia.—In this much may be done to alleviate the symptoms and increase the comfort of the patient by a persistent application of X-rays to the long bones, the sterno-costal articulations, and to the spleen. Under their application the blood-condition improves, and the myelocytes decrease numerically, the relation of red corpuscles to white more closely approximates the normal, and the nucleated reds decrease in number. Coincidentally with these changes the spleen decreases in size, and the patient so far recovers his health as to be able to resume his normal avocations.

The final prognosis, however, it must be admitted, is bad, but the alleviation of symptoms and the sense of comfort and well-being induced by the treatment justify steady perseverance, and earn the gratitude of the patient. The details of the treatment which I have found effectual are as follows:—

A Sabouraud dose is administered in turn to the front of the right tibia, front of right thigh, front of right arm, and right sterno-costal articulation, front of left tibia, front of left thigh, front of left arm, and left sterno-costal articulation; then back of right tibia, back of right thigh, back of right arm, back of left tibia, back of left thigh, and back of left arm, and finally to the spleen, fifteen Sabouraud doses in all. Then two to three weeks' interval and repeat. The length of time that this should be continued must depend upon the success the treatment affords, and the state of the blood, which should be examined at frequent intervals. A screen of aluminium 1 millimetre in thickness should be used to preserve the integrity of the skin.

Anterior Poliomyelitis.—Very gratifying have been the results of the use of electricity in this disorder, both by improving the general condition and modifying or curing the resultant paralysis. The earlier the treatment is commenced, the better the results will be, and the more readily will they be obtained, and permanent paralysis should be an uncommon result. "By a proper appreciation of the available therapeutic and mechanical agencies, we need rarely, if ever, encounter any paralytic deformity."[1]

There would appear to exist some difference of opinion as to when electrical treatment should commence, some advising waiting for weeks until after the fever subsides; the reason for this dangerous delay is not clear, and the reason against it is that compression is progressing in the cord and destroying cells and causing paralysis. The time to begin electrical treatment is the hour when the paralysis is first noted, whether the temperature has returned to normal or not. Much good, of course, can be effected at later stages, but the longer the delay the more treatment will be necessary, and the chances of complete recovery are proportionately lessened. Few diseases require more care and thought as to electrical treatment than infantile paralysis, and each case must to a great extent be judged on its merits, but as a general guide I would suggest this as a scheme for treatment: If the patient be seen early and is still in bed, a high candle-power light, followed by a high frequency effleuve or condenser electrode applied throughout the length of the spinal column: this with a view of reducing the congestion and compression of the nerve cells in the cord. A few days later the muscles themselves should be treated to prevent the muscle fibre from atrophying. Here the coarse-wire faradic rhythmically interrupted is excellent. Two sponge electrodes should be used, one at the origin of the muscle involved and one over the insertion (sometimes this may be varied by placing one of the electrodes over the motor point). For instance, in treating the peronei the leg should be supported, the foot flexed as much as possible so as to relax the muscles, one electrode over the middle third of the outer side of the fibula and the other over the insertion of the muscle on the outer side of the foot.

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[1] *The Surgery of Paralysis*, p. 41. Tubby and Jones.

The strength of the current should be the weakest that will produce contraction—three minutes is enough for each muscle, and fifteen minutes should be looked upon as a maximum time for the muscle stimulation, even if several muscles or groups of muscles have to be treated.

Later, when the child is able to leave home and visit the physician, static electricity in the form of the static wave to the back, applied in the same manner as in Locomotor, should be used. In all these forms there should be no pain caused to the child, and he should never be frightened or made tired. It is unfortunately not always that the disease is attacked from the first, and it happens that the patient is not seen until the paralysis has been existent some time. Here static electricity should be employed from the first both to spine and possibly to the muscles at fault, or perhaps these latter may be left to a carefully-educated mother to attend to at home with the faradic apparatus already mentioned. I do not wish to be taken as saying the treatment of anterior poliomyelitis should be purely electrical: muscle education and massage are of great importance. Dr. Henry Frauenthal, an eminent orthopædic surgeon of New York, in whose clinic I have seen some of the most astonishing and brilliant results, once told me that the percentage of good accomplished from the different agents he used would be about—electricity, 55 per cent.; muscle education, with mental concentration on the physical effort, 25 per cent.; and 20 per cent. from muscle stimulation by massage.

Tubercular and other Infected Glands.—In tubercular glands X-rays are often of decided benefit. Whether they act by only sterilizing the bacillus, and so inhibiting the tubercular process, or whether by causing the dead tubercle bacilli to act as an autogenous vaccine, is a matter of academic rather than practical interest. In favour, however, of the latter hypothesis, it will often be noticed that after an irradiation of the glands, constitutional effects precisely similar to those which follow a vaccine injection may be observed, and that the more marked these are, the greater the benefit from the treatment. One full Sabouraud dose should effect an improvement, though this may be given in three or four divided doses, with the skin protected. This dose may be repeated from time to time at proper intervals; the number of repetitions must depend upon the amount of improvement gained. The gland should eventually be reduced to a small hard lump of fibrous tissue. I have not treated any cases *after* suppuration has occurred, such having been referred to the surgeon, though I have rayed the neck post-operatively as a prophylactic measure, but my friend, Dr. James Metcalfe of Bradford, has treated many such, and finds that old broken-down glands and tuberculous sinuses have often healed up remarkably well.

For the treatment of non-tubercular glands (simple adenitis) I rely upon auto-conduction method of the Oudin current, or the high-power vacuum from the static. The former is more powerful, and the technique may be described thus:—

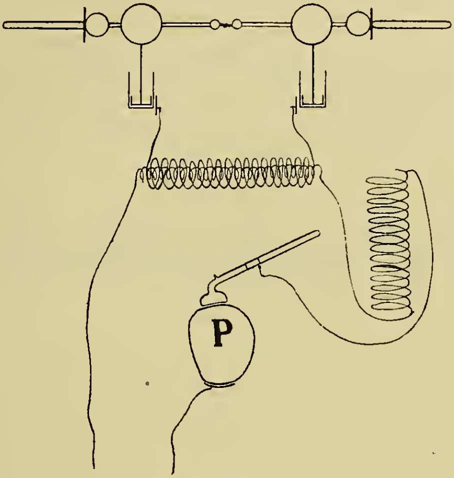

Fig. 53.
Diagram of the Oudin Current.

The current from a powerful static machine is led into two Leyden jars, from the outer covering of which it is passed into a primary spiral of stout copper wire. Inside this is another spiral of a great number of turns, well insulated. This forms a secondary or Tesla coil, of which one end is earthed and the other led to a resonator of many turns of rather coarse wire (the Oudin Resonator). From the other end of this resonator is led a wire connected with a glass vacuum electrode, which is placed in apposition to the part of the patient to be treated. Elsewhere on the patient's body is a piece of metal about 10 inches square, which is earthed (Fig. 53). The gland should be gently massaged with the glass vacuum electrode for about ten minutes daily, or on alternate days, and the swellings will begin to diminish in size from the first few treatments, until they finally disappear.

Stricture.—The principle of the treatment of this condition by electricity is that at the negative pole of the constant current a dissociation of tissue is effected, known as electrolysis. Hydrogen and the alkaline elements are liberated, and it has the effect of an alkaline caustic; the hydrogen escapes as bubbles of gas, the portion of disorganized products remaining in the tissues act as a foreign body, and are gradually absorbed.

The electrode required for the positive is a large dispersive pad, upon which the patient lies on his back, the negative is attached to a rubber bougie, which is provided with a set of olive-shaped metal tips of varying sizes (Fig. 54).

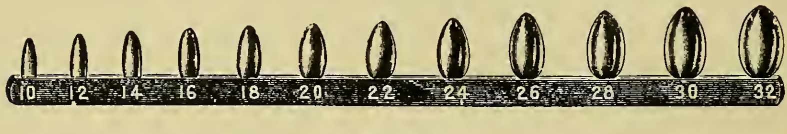

Fig. 54.

The technique is as follows:—

The size of the stricture having been previously ascertained, the patient is placed in position and a tip adjusted to the bougie, one size larger than the stricture, and gently passed down the urethra so that it rests upon it. Turn on the current very slowly until the meter registers 2–3 ma., and then wait a little, when, if the patient complains of no pain, the current may be gradually increased until 5 or 6 ma. are reached. No appreciable pressure is used, but the electrode is allowed by its own weight to pass through the stricture; this it will usually do in about ten minutes. Cocaine should not be used, and there is no need for it, since the treatment is painless. When the tip slips through the stricture, gently draw it through the stricture from behind forwards—it will usually come quite easily. Slowly turn off the current, and remove both electrodes. A froth of hydrogen bubbles will be seen on the bougie and at the mouth of the urethra. This process should be repeated once a week, using a larger electrode each time, until the stricture is entirely dissolved. This method is unsuitable in those strictures which bleed readily on being touched. Quite recently Professor Neiswanger of Chicago has been using Thiosinamin (allyl-sulphocarbamide) by cataphoresis for the removal of scar tissue in prostatic hypertrophy—urethral strictures, &c. The solution he uses is as follows:—

℞

Thiosinamin (Merck)	gr. xlv.
Glycerine	ʒ ii.
Aq.	ʒ vi.
Sod. Chlor.	grs. v.
	m.

He used it from the positive pole for about ten minutes, with a current strength of 5 to 20 ma., and using a special electrode. Trials are now being made, and it may be that a valuable addition will be made to our armamentarium.

Dupuytren's Contraction.—Possibly Thiosinamin will prove a remedy for this very obstinate affliction, for which surgery would seem at present to be the best remedy. I have, however, obtained favourable results with chlorine and iodine ionization. I immerse the hand in a dish of a solution of Sodium Chloride and Pot. Iod., and colour it with Tr. Iod. The strength is not of much importance, so long as it is over 2 per cent. The leg of the same side is placed in a porcelain leg-bath (one from the Schnée chair is very convenient), and a current is slowly turned on up to the toleration of the patient, usually 35 to 50 ma. This is allowed to flow for one hour. The treatment should be repeated once or twice a week. The process is a slow one, and should only be employed when an operation has been refused.

Exopthalmic Goitre.—In this disease, when so little can be done in many cases in the way of ordinary medication to strike at the root of the morbid state, it is fortunate that in electricity some means can often be found to assuage the sufferings of the patient, to limit the extent of the disease, and in some cases to effect what appears to be a symptomatic cure. When we look at the pathology it is easy to see why electricity should be looked upon as a rational remedy. The remote, and as yet undiscovered, first cause is probably to be found in the central nervous system, but the first pathological step in the disease that has been at present demonstrated is the change in the thyroid gland. The thyroid arteries becoming dilated, promote a vascular congestion, which results in its hyperplasia. In X-rays we have one agent which tends to set up an obliterative arteritis, thus combating the enlargement of the thyroid arteries, and in the static wave current we have another which, by the successive contractions and relaxations which it induces, causes active tissue gymnastics throughout the gland, thereby relieving the vascular congestion and infiltration, and removing inflammatory products, thus restoring normal circulation.

X-rays should be given to the maximum dosage with the skin protected—a full Sabouraud dose in divided portions once a month to each side and to the central lobe.

The wave current should be administered by placing a metal electrode over the thyroid gland and securing it in place by a bandage around the neck. The spark-gap should be opened with extra caution, and slowed down to avoid tonic contraction of the muscles, which, however, should be made to contract and relax energetically. The application of the wave current should last about twenty minutes. The two treatments should, as a rule, be given concurrently, and be continued over a long period of time. Improvement will be early manifest, and the patient will say that the palpitation is lessening, and a sustained diminution of the pulse rate will be noted. Sometimes it happens that the size of the growth may remain unaltered for months, but the palpitation has subsided, the nervousness and trembling have gone. Iodine cataphoresis has also been recommended, but unless the patient is rapidly losing weight or is suffering from an intractible anæmia, or where there is mental derangement, a fairly favourable prognosis may be given if the patient is treated in the manner described.

There are several diseases which might properly be included in this chapter, more especially diseases of the Eye—such as Optic Atrophy and Early Cataract; of the Ear—Deafness and Tinnitus, in which good results have been obtained, but the electrical treatment of which has not yet withstood the test of time sufficiently to publish it at present.

CHAPTER XXV

ON BLOOD-PRESSURE[1]

The importance of the early recognition of any abnormality of the blood-pressure, and of any treatment which will favourably affect such abnormality, is fortunately now well recognized. With the aid of the Sphygmomanometer any deviation is easily detected.

By the method by which we were all originally taught of estimating arterial tension by the pressure of finger-tips over the radial artery much valuable information may be gained, and to some a certain skill has been given by which this information is wonderfully accurate. But to the average medical man, and to him more especially in the early years of his career, the accuracy of the finger method compared with the modern sphygmomanometer is probably quite comparable to that of the estimation of the body temperature by a sense of touch instead of by the clinical thermometer.

"Science is measurement," and if it be of advantage to note the blood-pressure, or to estimate tension when feeling the pulse from time to time in the course of the disease, how much more is it of an advantage to be able to make an accurate estimate, and to record the result in millimetres?

Although an altered blood-pressure is only a symptom, and not a disease *per se*, it is a symptom of such importance that in some cases diagnosis and prognosis may be decided by it, and in others treatment may be modified by its variations. And, again, it may be in itself a symptom which urgently calls for relief.

"A man is as old as his arteries," and if it were only that an alteration in blood-pressure gave a warning of advancing years, that fact alone would justify attention to the subject-matter of this chapter. There are, however, many conditions resulting from, or concurrent with, an alteration in arterial tension that make the subject interesting as well as vital.

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[1] Much of this essay appeared in the *Clinical Journal*, March 1911, under the title of "The Significance of Sphygmomanometric Readings."

Increased arterial tension is in all probability responsible for the degeneration of the muscular walls of the arteries; in fact nothing else can be conceived, if granted the pathologically increased tension on the persistently-contracted arterioles, than that metabolism and nutrition of the muscular structure of the arteries should suffer. Muscles in any part of the body degenerate under constant tension or contraction.

The importance of early recognition of the altered blood-pressure is, therefore, obvious; if we can recognize the pressure before it has had time to cause the degeneration, then we may, by the various therapeutic measures, diminish that pressure and thus avoid the otherwise resultant degeneration.

In some cases where the blood-pressure is giving rise to nervous trouble we can, I believe, by approximating the blood-pressure more nearly to the normal, prevent those troubles from ending in permanent disease, and from crossing that border-line between nervous disease and mental derangement to which they are slowly but surely progressing.

An alteration in arterial tension is probably caused by unusual stimulation of the vaso-motor system. This may be due either to the circulation of irritants, such as alcohol and toxins, in the blood-stream, or to some central nervous stimulation of the vaso-motor centres due to trouble in the brain or spinal cord.

Normal blood-pressure depends upon four factors: (1) The heart's energy; (2) the peripheral resistance; (3) the elasticity of the vessel walls; (4) the volume of the circulating blood.

High tension means a powerful ventricular contraction with contracted arterioles, just as low tension means a weak cardiac action with the dilated arterioles. And here I will submit a list, modified from Leftwich, of some of the conditions under which we may expect to find altered blood-pressure—

High Tension

Arterio-sclerosis.
Angina pectoris.
Aortic aneurysm.
Chronic bronchitis.
Cirrhosis of kidney.
Cerebral tumour (first stage).
Chronic alcoholism.
Constipation.
Cerebral hæmorrhage.
Cheyne-Strokes' breathing (which, with high tension, is ominous).
Dilatation of aorta.
Emphysema.
Glycosuria.
Gout.
Hemicrania.
Hypertrophy of heart.
Hysterical seizure.
Lead poisoning and other toxæmias.
Malaria (cold stage).
Meningitis.
Migraine.
Neuralgia and other conditions of bodily and mental sufferings.
Pregnancy.
Pleurisy, acute (first stage).
Uræmia.
All kidney affections except amyloid, suppurative, and tubercular, except in terminal stages, when cardiac weakness causes a fall.
A too nitrogenous or too liquid diet.
Insanity with depression, including general paralysis of the insane. Also found in healthy but apathetic individuals. Certain drugs may act in raising pressure, adrenalin (especially when injected), caffein, strychnine, and camphor.
Cold weather.
Descending galvanic current.

Low Tension

Addison's disease.
Anæmia.
Aortic stenosis.
Asthma.
Alcoholic delirium.
Chlorosis.
Cachexia and wasting diseases.
Dementia, especially post-epileptic.
Dilatation of heart.
Diabetes.
Diarrhœa.
Exhaustion.
Fatty degeneration of heart.
Febrile conditions, especially typhoid.
Diphtheria.
Influenza.
Neurasthenia.
Profuse hæmorrhage (except cerebral).
Jaundice.
Obesity.
Pleurisy (second stage).
Pulmonary tuberculosis, especially in late stage.
Pyrexia.
Trypanosomiasis.
Shock and collapse.
Also by hot drinks, hot air, and by the action of certain drugs, such as amyl nitrite, chloral, cannabis indica, nitro-glycerine, erythrol tetra-nitrate, hedonal and sodium nitrite, veratrum viride and aconite, iodides and hippurates, and any drastic or hydrogogue purgative; also by radiant light-baths, and by the use of certain high-frequency currents and an ascending galvanic current.
Insanity with mania.
Lowered atmospheric pressure.
Warm weather.
Starvation.

And with many diseases, their cause, favourable or unfavourable, varies with the blood-pressure, and thus the advantage of being able to note accurately the effect of treatment upon the blood-pressure is in line with such other scientific observations as we may make.

Treatment must be directed in all cases not only to the approximation of the blood-pressure to the normal, but also to the ascertaining of the cause or its removal; and though the cause, be it dietetic, hygienic, toxic, or what not, is of prime importance, this is not the place to discuss it; it is mentioned to emphasize its significance.

Unless the abnormal tension be compensatory, efforts should be made to reduce the abnormality.

One word should be said about the normal maximum arterial tension in advancing years. It is usually taught that its rise with advancing years is normal. True it is that as a man gets older his tension usually rises, but is it that his tension rises, not on account of his years, but on account of something wrong in his health, and should not a man who has always lived a healthy, active, abstemious life have the same blood-pressure at sixty as he had at thirty? . . . I think so. And with the onset of a rise in tension the cause should be sought, and the tendency corrected.

It is generally conceded that electrical currents have the power of modifying pathological arterial tension, and yet have little or no effect upon normal blood-pressure (indeed the same has been observed of the action of digitalis[1]). It has already been pointed out that in a slight degree the static bath will approximate to the normal either an increased or a decreased blood-pressure, but for greater effects other currents must be employed. The precise way in which these act has not yet been fully determined, but this much may be taken for granted, that their action is upon the muscle fibres of the arteries, either upon these directly or indirectly through the vaso-motor centres. In practice, if we wish to raise an abnormally low blood-pressure, the static brush applied to the spine, as described in the chapter on neurasthenia, will be found fairly effectual. Static sparks in obstinate cases will produce a definite effect perhaps in a shorter time.

Some observers (Moutier, Albert Weil, and others) have recorded a rapid rise in blood-pressure from the effect of sparks from the Oudin Resonator, and Schnée states that the ascending galvanic current will raise the tension; my own experience, however, has been confined to static currents, and I have often noticed that where the rise is only fractional, the symptoms for which the patient comes seeking relief are markedly abated after a few treatments. But more commonly it is a high arterial tension which is sought to be lowered than a low tension raised, and it is here that D'Arsonvalization has a wide sphere of usefulness. In the high tension associated with rheumatism, gout, chronic alcholism, and many other diseases, even in arterio-sclerosis, a reduction in the blood-pressure can be obtained, and coincidentally there is evidence of increased oxidation. The output of urea is increased, and uric acid diminished—that is to say, nitrogenous matter becomes more completely oxidized.

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[1] Czyhlarg, *Wiener klinishe Rundschau*, April 15, 1900.

The manner in which the current is applied varies with the operator. As far as effect is concerned, the auto-condensation cage and the auto-condensation couch give equally good results; and, as will be seen from the diagram, in construction the two forms are much alike.

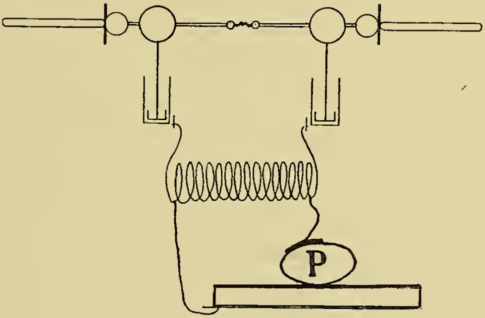

Fig. 55.

The cage is more cumbersome, and somewhat alarming to the nervous patient, and my preference is for the couch. A current of 500 to 1000 milliamperes or more may be passed for ten minutes, or until the patient flushes or the skin becomes moist. The treatment should be daily or thrice weekly according to the nature of the case and the readiness or otherwise with which it responds to treatment. Frequent readings with the sphygmomanometer should be taken as a guide to the treatment. Headache and a feeling of lassitude are sometimes noted after the first one or two treatments.

These are due to the fact that, in consequence of the rapid tissue change induced by the treatment, more toxins are liberated than can be carried off normally. These effects will be more marked if constipation be present, and altogether avoided if the bowels are kept freely open.

Latterly I have been using the thermo-penetration method in order to lower a high blood-pressure. The method is somewhat more simple. The patient holding the two handles.

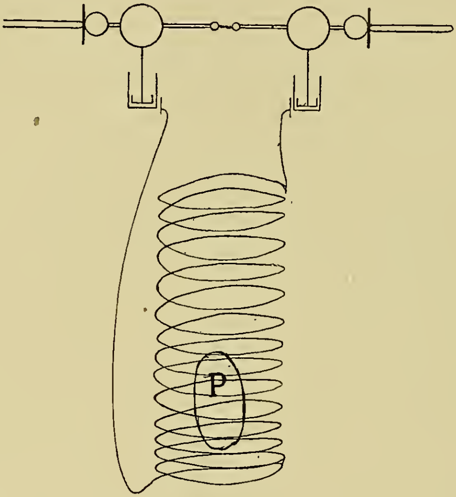

Fig. 56.

It is quieter and less alarming than with the noisy spark-gap of D'Arsonval. It does not give such consistent results.

The importance of an agent which is able to lower a high arterial tension can hardly be overestimated. If we can hope to keep the arteries "young," help to ward off mental disturbance in neurasthenics, diminish the chances of an unfavourable end to a case of nephritis, or to forestall an attack of apoplexy by any agent, that agent is worthy of grave consideration. These things are possible if we can lower arterial tension, and in most cases arterial tension can be lowered by electrical currents properly applied.

CHAPTER XXVI

LESSONS FROM FAILURES

("*On apprend en faillant*")

When reading various books and articles (and I do not except my own) written on electro-therapeutics, one might almost imagine that failures were not encountered in this branch of medical healing, and it may well be that in early training under masters of this branch of medicine, the learner sees no failures. Even perchance in his early days of practice, following closely in the footsteps of his teacher, the beginner knows "no such word as fail"; and though this may be true of the lexicon of youth, in the dictionary of a well-spent middle-age the word does occur from time to time. And it is well that this should be so. Samuel Smiles truly said, "We learn wisdom from failure much more than from success; we often discover what *will* do, by finding out what will not do, and probably he who never made a mistake never made a discovery."

I propose in this short chapter to draw lessons from failures in my own practice rather than to dogmatize about failures in general. Some of my early failures I know now were due to the causes upon which I have dilated in another chapter: lack of a full armamentarium and an adequate knowledge of how to use what I had. Certain it is that a full armamentarium adds not only to the comfort of working, but also to the percentage of success. How should we expect to stand in the front rank of medicine if we were limited in our prescriptions to three or four drugs? We should certainly get results if we had only castor oil and opium—and I can think of no more useful couple—but we should not get that percentage of successes in all cases in which we might hope for it with all the drugs of the Pharmacopœia at our disposal. Similarly it may be argued that even with all these resources, they would avail but little unless there were a careful training and study in the scientific use of them. It may be said that these are platitudes, but I have known a case where a high frequency apparatus was ordered and the treatment was going to be given by an operator who up to the hour of his starting the appliance had never seen any high frequency, or any form of electricity. I will admit this is an extreme case, but I know of other cases where electricity is administered with a lack of knowledge of its administration with which a drug would not be touched. And the public will with equal devil-may-care feeling go to an "electric establishment" and allow unqualified people to administer that powerful agent—Electricity—an agent which they know is capable of killing them, when they would certainly not allow any but the most carefully-selected physician or surgeon to attend them for ailments however trivial. But the lesson to be drawn from these last is, I fear, not for this day or generation.

Perhaps one of the most frequent causes of failure is the undertaking of cases unsuitable for treatment by electricity. In 1904 I was having an unbroken run of success with the treatment of chronic constipation by means of static electricity, and I was getting the belief that it was an infallible remedy, when I undertook the case of a lady and failed to effect the desired result. As I had not had a failure in chronic constipation I persevered with the static wave current, and later with the static induced, but the constipation remained. I then discovered that the patient had a badly retroverted uterus, and that until that had been placed in a better position she would of necessity have trouble. Two other cases illustrative of the necessity of seeing that the case is suitable occurred to me in the treatment of obesity by the Bergonié method.

In two cases I failed to get the reduction of the 2½ to 3½ lbs. a week which I expect, and, I may say, usually obtain, but on careful inquiry in order to ascertain the cause of the unusual lack of response to the treatment, I found in one the patient had reduced herself some 40 lbs. before coming to me, and though somewhat overweight, was down to an irreducible minimum; the other case thought she was getting fat, and it was only when I found that the treatment was not reducing her weight that I carefully went into the matter of height and weight, and found that in reality she weighed less than normal.

Another cause of avoidable failure is persevering in the face of want of success. It may be that this may be criticized, and the statement be countered with ancient saws such as "If at first you don't succeed, try, try again." It may be that such criticisms are justified, but my practice is as far as possible to discontinue treatment if no beneficial results are apparent from the first. Good results are obtained in nine out of ten cases. It may be said that this rule falls hardly upon the ten per cent. who are to be shut off from a possible benefit, but I think that in that ten per cent. the chance of benefit is remote, and that if electricity is going to do good, the good effects will be early manifest. There are few more discouraging things, both for the patient and physician, than to go on with daily electrical treatment with the symptoms showing no sign of abatement. It cannot add to the credit of electricity or to the reputation of the doctor, nor is it likely to alleviate the sufferings of the patient.

It may be that, as regards the ten per cent., that in the patients themselves there exist some unknown factors contra-indicating the treatment. What is the lesson in such cases? I think it is this: that there are, and must be, cases which will not respond to treatment, and an early recognition of this is not the failure that unsuccessful persistence becomes.

Another cause of failure is inattention to detail. This, of course, is true in other branches of medicine, but one is apt in the course of an extensive electro-therapeutic practice to overlook some small point whereby the success of the treatment is imperilled. When we find a patient not responding as readily as we expect, every trifle must be examined, whether in the apparatus, the method of using it, or in the patient's condition and daily life. "He who fails in one particular fails in the whole action" (*Qui cadit a syllaba cadit a totâ causâ*) is a legal axiom, held now, I believe, to be erroneous in law, and it may be erroneous in the practice of electro-therapeutics; for it is possible to get results, and good results, with inferior apparatus, an inadequate knowledge of how to use it, and a lack of medical knowledge of the patient's constitution and anatomy. But we shall not get the uniform effects if we fail in the one particular. From time to time failures will occur which can only be avoided by scrupulous attention to detail.

In some cases in which success has failed to crown my efforts, on looking back I have found that the cause has been over-confidence. This has occurred when there has been a run of successful cases and everything has been going well for weeks perhaps at a time, or when, after an annual meeting, or reading an optimistic article in a journal, a case has been undertaken, and the patient assured that there is every reason to expect success—and disappointing results follow.

Yet the converse, lack of confidence, is even more disastrous: "All fails where faith fails" (*Alles wanket wo der Glaube fehlet*). I will admit it is difficult to strike a happy mean between these two, but it must be done in order to be successful, and proficiency in electro-therapeutics depends upon it to a great extent.

One cause of failure which I have found to be very common is what I shall call, for lack of a better phrase, patients "presuming on the treatment," and this they often do in all innocence; but it is a danger against which they should be warned. Several classes of case occur to me: one is the neurasthenic with a low blood-pressure who comes complaining of want of energy, and of always feeling tired. He or she begins to improve say under the static brush on the spine, a certain amount of energy is developed, and the patient joyfully begins to do more, and soon does too much, using up the energy developed under the electrical treatment instead of storing it up for the restoration of health.

So, too, is it with sciatica and other forms of neuritis; the patient, finding relief from pain, will presume on the treatment by giving the affected part too much exercise, and so returns little, if any, benefited; whereas if he had reasonably rested the limb, a second exhibition of electricity would have begun where the first had left off, and so on until a complete restoration to health had been effected.

Yet another case is that of the dyspeptic, who at the first sign of improvement thinks he is altogether cured, and straightway goes and gives himself enough cause for more indigestion. All these patients should be told to do no more in the way of fatigue, exercise, eating, or what not, than they were doing prior to commencing electrical treatment, at any rate at first, or until permission is given them.

Allied to this class is another in which I have met with, and retrospectively can say deserved, ineffectual conclusions. This class comprises patients living at a distance. Here the fatiguing effort involved in the journey neutralizes the benefit of the treatment. It is very difficult to know where to draw the line; in fact it is impossible to say how much fatigue balances how much therapeutic effect. Each case must rest on its merits. It may sometimes be necessary for the patient to come once or twice, so that it may be seen which swings the needle farthest from the centre, the positive good of the treatment or the negative harm of the fatigue entailed in reaching it.

Failures have occurred, and doubtless will occur again so long as infallibility remains unconferred upon us, from mistaken diagnosis. Two cases have happened quite recently in my practice: one was a shoulder, and one a knee—both referred to me as rheumatic joints. In each case the appropriate treatment for such cases failed to relieve the symptoms, and on taking a radiogram the origin of the trouble was in one case a small chip of bone due to an injury thirty years ago, and in the other a small exostosis. The lesson to be learned is clear: it is to have a careful X-ray examination made of all obstinate cases, and most of those cases in which the diagnosis is not absolutely certain and clear. It is more satisfactory to the patient, and certainly a more scientific procedure for the practitioner.

I now come to a class of case—happily rare—in which our labours are in vain. This is where patients are idiosyncratic with regard to electricity. They fall into two divisions: those who suffer from electrophobia, and to whom electricity and everything connected with it is *anathema maranatha;* and the other who have a true idiosyncrasy. For a long time I denied the existence of this latter, but several cases compel me to acknowledge its existence. Two cases will illustrate my meaning: one was a case of neurasthenia with symptoms typical if complex. The patient was most anxious to get well, and persevered with the treatment, and there was just enough improvement to justify its continuance. However, after several weeks' faithful attendance, we had to admit that a cure was not in sight. This patient afterwards told me electricity never had suited him, although he had tried it previously in many forms, but that he had concealed the fact lest it might lead me to decline to undertake the case. Another instance was that of a lady who was very anxious to be relieved of some superfluous weight. She was a subject apparently in every way suitable, but after a month's treatment she weighed but 7½ lbs. less than at the beginning. She then told me that electricity had never had good results, not only with her, but it had never done good to any of her sisters, who had had it administered for various ailments; and as long as it is admitted that certain people have an idiosyncrasy where drugs are concerned—witness the familiar examples of quinine, opium, the iodides, &c.—it is only reasonable to suppose that there are here and there those who have an idiosyncrasy in the matter of electricity. Fortunately, however, they appear to be rare. Rarer still are the patients with electrophobia, and this is hardly to be counted as a cause of failure since they do not often come under our care. However it is a state which should be borne in mind, since a patient suffering from it may be overpersuaded by another grateful patient, or a parent who has benefited by electrical treatment may coerce a child, or a husband a wife, to try and reap benefit: but if the unreasoning fear is there, it will more than counterbalance the good that the treatment will do them.

I hope that this chapter is not too pessimistic; it is not so intended. It is written that others may avoid some of the pitfalls into which I have fallen, and that success rather than failure may occur in even a higher percentage of cases than before.

GLOSSARY

ACCUMULATOR.—(1) A secondary or storage battery ; (2) a Leyden jar or condenser.

ACTINIC RAY.—A ray of light or other form of radiant energy possessing the power of producing chemical action.

ACTUAL CAUTERY.—A cautery produced by the agency of a substance physically hot, *i.e.* not a chemical caustic or fulguration.

" ALIVE."—An active wire or circuit.

ALTERNATING CURRENT.—Currents whose directions are periodically reversed.

AMALGAMATION.—The act of effecting the combination of a metal with mercury.

AMMETER, OR AMPEREMETER.—Any form of galvanometer which is capable of measuring current strength in amperes.

AMPERAGE.—The strength of the electric current measured in amperes.

AMPERE.—Unit of strength of the electric current ; it is that afforded by an electromotive force of one volt against a resistance of one ohm.

AMPERE HOUR.—A term used to determine the quantity of electricity which would be carried by one ampere in one hour.

ANÆSTHESIA, ELECTRIC.—Nervous insensibility obtained by electrical means.

ANAPHORESIS.—Is the driving into the tissues by means of an electric current those substances which are electro-negative.

ANDIOMETER.—A form of induction balance employed in testing the acuteness of hearing.

ANELECTROTONUS.—The condition of increased excitability which exists in a nerve when traversed by an ascending current.

ANION.—(*Ana*, upward, *ion*, traveller.) An electro-negative ion, so called because it appears at the anode when set free by electrolysis.

ANODE.—The positive pole of an electric battery or the electrode connected with it.

ANODIC CONTRACTION.—The muscular contraction produced in the neighbourhood of the anode either on opening or closing the circuit.

ANTICATHODE OF X-RAY TUBE.—A plate, usually platinum, supported inside an X-ray tube to receive the cathodic bombardment.

APERIODIC.—Coming to rest steadily without oscillations.

APERIODIC GALVANOMETER.—A galvanometer whose needle comes to rest without any oscillation.

ARC LAMP.—An electric lamp whose source of light is the voltaic arc.

ARMATURE.—The keeper of a magnet. A mass of soft iron in contact with both poles of a magnet in order to prevent loss of magnetic forces.

ARMATURE OF A CONDENSER.—A term applied to the metallic plates or coatings of a condenser or Leyden jar.

ARMATURE OF HOLTZ MACHINE.—The pieces of paper that are placed on the stationary plate of a Holtz machine.

ASCENDING CURRENT.—The current applied by placing the positive electrode to the periphery of a nerve, and the negative near the nerve centre.

ASTATIC GALVANOMETER.—A galvanometer provided with a pair of oppositely magnetized needles, so as to be independent of the earth's magnetism.

ASYNCHRONOUS.—Occurring or acting non-simultaneously.

ATMOSPHERIC ELECTRICITY.—The free electricity which is present in the atmosphere.

ATOM OF ELECTRICITY.—A quantity of electricity equal in amount to that possessed by any chemical monad atom.

ATTRACTION, ELECTRICAL.—Attraction shown by substances for one another when charged with an opposite variety of electricity. The act of drawing together.

ATTRACTION, MAGNETIC.—The force by which a magnet draws to itself certain bodies.

AURAL ELECTRODE.—An electrode suitably shaped for the therapeutic treatment of the ear.

AUTO-INDUCTION.—A word sometimes employed instead of self-induction.

AUTOMATIC CUT-OUT OR SWITCH.—A device for automatically cutting off the current on the occurrence of any predetermined event, such as a clock in circuit reaching a given hour.

B. & S.—Brown & Sharp U.S. wire gauge (this scale does not vary very much from the B.W.G.).

BACK INDUCTION.—An induction opposed to the field, and tending to weaken or neutralize it.

BAD EARTH.—A term applied to a bad ground, or connection to earth whose electric resistance is comparatively high.

BASE.—The part of a battery upon which is fastened the coil and binding posts, switches, &c.

BATTERY.—Apparatus for generating or storing electricity.

BATTERY SOLUTION.—The exciting liquid or electrolytic of a primary or secondary cell.

BICHROMATE CELL.—A zinc carbon couple employed with a solution of bichromate of potash and sulphuric acid in water.

BINDING POSTS.—Clamps for connecting conducting wires with the electrical apparatus.

BIPOLAR.—Having two poles.

BIPOLAR BATH.—A bath, the current supplied to which enters at one part and leaves at another.

BLOWING A FUSE.—The fusion of a fuse wire by currents passing through it.

BOBBIN, ELECTRIC.—A coil of insulated wire suitable for the passage of an electric current.

BRANCH CIRCUITS.—Additional circuits or a shunt circuit.

BREAK (noun).—(*a*) An arrangement for interrupting, *i.e.* breaking or making a current ; (*b*) any lack of continuity in a circuit.

BREAK (verb).—To interrupt or open a circuit, opposed to make or close the circuit.

BREAKING THE PRIMARY.—Opening or breaking the circuit of the primary of an induction coil or transformer.

BREEZE, ELECTRIC.—A brush discharge employed in electrotherapeutics.

BRIDGE, ELECTRIC.—A device for measuring an unknown resistance by comparison with two fixed resistances and an adjustable resistance.

BRUSH (*a*).—A metallic electrode for localized electrization, used with the faradic current (of small therapeutic value).

BRUSH (*b*).—Discharge, *q.v.*

BRUSH (*c*).—Static brush discharge, *q.v.*

BRUSH (*d*).—In dynamo, *q.v.*

B.T.U.—The energy contained in a current of 1000 amperes flowing for one hour under a pressure of one volt.

B.T.U.—A contraction for Board of Trade unit.

BUCKLING.—The warping of the surface of the plates of storage cells by a too rapid discharge.

BUNSEN CELL.—A zinc carbon couple whose elements are immersed respectively in electrolytes of dilute sulphuric and strong nitric acids.

BURN OUT.—The destruction of any part of an electric apparatus by excessive current due to short circuit or other cause.

B.W.G.—Birmingham Wire Gauge.

CALIBRATE.—To determine the absolute values of scale divisions of an electrical instrument such as a galvanometer, voltmeter, wattmeter, &c.

CANDLE-POWER.—The intensity of light emitted by a luminous body estimated in standard candles.

CAPACITY OF CONDENSER.—The quantity of electricity a condenser is capable of holding in coulombs when charged to a pressure of one volt.

CAPACITY OF LEYDEN JAR.—The quantity of electricity a Leyden jar will take under unit difference of potential.

CATAPHORESIS.—(*Kata*, down, *phero*, I drive.) The act of transferring remedial agents through the skin, mucous membrane, or open surface by means of the positive pole of constant current; such agents being electro-positive.

CATELECTROTONUS.—Increased excitability or irritability of a nerve at the negative pole when traversed by a constant current.

CATHODE.—(*Kata*, down, *hodos*, a way.) The negative pole of an electric battery, or the electrode connected with it.

CATHODE RAYS.—Rays originating in a vacuum tube at the negative terminus when a suitable discharge of electricity is passed through the tube. They are not identical with the Röntgen rays, since they are deviable by a magnet and by refracting media, and are rapidly absorbed by opaque bodies and by the atmosphere.

CATION.—(*Kata*, down, *ion*, a traveller.) An electro-positive element, so called because it appears at the cathode when set free by electrolysis.

CAUTERY.—(*a*) Galvano cautery, a form of actual cautery, is one in which the wire is made hot by means of the galvanic current. (*b*) Solar cautery, a lens for concentrating the sun rays, used for the removal of warts and other small growths, said to be useful in lupus.

CELL.—The jar, cup, or container which holds the elements, and the agent which produces a difference of potential between them.

CELL SELECTOR.—A device which brings into action any desired number of cells.

CIRCUIT.—The path of a current from one pole to the other of a battery or electric machine. A term employed in a galvanic circuit; the term includes the elements, battery fluid, conducting cords, electrodes, and any intervening substances or body.

CIRCUIT (BROKEN).—A term employed when the path of the current is interrupted.

CIRCUIT (CLOSED).—A term employed when there is no impediment to the current, and it flows either by direct current or through a good conductor.

CIRCUIT (INTERRUPTED).—A term employed where the circuit is rapidly and alternately broken and closed.

COIL, INDUCTION.—A double wire coil—one, the primary, of coarse wire; the other, the secondary, of very fine wire outside the first and insulated from it. A current is induced in the latter on breaking and on making the circuit in the inner or primary coil.

COMMUTATOR, CURRENT REVERSER.—A piece of apparatus for reversing the direction of the current flow.

CONDENSER.—An apparatus for accumulating or storing a large amount of electricity on a surface.

CONDUCTIVE DISCHARGE.—*See* DISCHARGE.

CONDUCTOR.—Any substance which conducts or possesses the power of conducting electricity.

CONTINUOUS CURRENT (also called Direct).—A current whose direction is constant as distinguished from an alternating current.

CONTRACTION (CLOSING).—Muscular contraction produced at the moment the circuit is *closed*.

CONTRACTION (OPENING).—Muscular contraction produced at the moment the circuit is *opened*.

CONVECTIVE DISCHARGE.—*See* DISCHARGE.

COULOMB.—Is that amount of electricity which is carried by an ampere flowing for one second past any given point in the circuit. There are 3600 coulombs in one ampere hour.

CURRENT :—

ALTERNATING.—Is one in which the current is being continually reversed in direction at short intervals.

ASCENDING OR CENTRIPETAL.—Positive to periphery, negative to nerve centre.

CHANGER.—Pole reverser.

CONTINUOUS.—Constant, galvanic.

DESCENDING.—Centrifugal in contrast to the ascending.

FARADIC.—An induced current of an alternating nature.

HIGH FREQUENCY.—*See* D'Arsonval, Tesla, Oudin.

LABILE.—Current in which the electrodes are moved over the surface to be treated.

OSCILLATORY.—A current is said to be oscillatory when it flows in opposite direction, for periods regular or irregular.

PULSATORY.—A current is said to be pulsatory when it flows in one direction only, but there are intervals between the current waves.

RECTIFIER.—A term sometimes applied instead of transformer to an instrument which commutes an alternating current into a direct current, or *vice versâ*.

SINUSOIDAL.—Is one which rises from zero to a maximum and falls away again, to be followed immediately by a reversed current, which also rises and falls in the same manner; thus its poles are ever changing.

STABILE.—Current in which the electrodes are held in a fixed position.

CURRENT, ELECTRIC.—(*Curro*, I run, I flow.) The transfer of electricity along a conductor.

CURRENT SELECTOR.—The name applied to any device which brings a current into action.

CURRENT STRENGTH.—In a direct-current circuit the quotient of the total electromotive force divided by the total resistance, or $C=\frac{E}{R}$.

CURRENT TRANSFORMER.—(*a*) An instrument for changing an alternating into a direct current, or *vice versâ*; (*b*) a device for altering the pressure of a current.

DAMP.—To introduce some retarding force to lessen energy of motion.

DANIELL'S CELL.—A typical galvanic cell, consisting of a porous cup containing dilute sulphuric acid immersed in a jar containing a solution of sulphate of copper ; the elements are copper and zinc.

D'ARSONVAL.—A charge of high potential from a condenser through a solenoid.

DEAD-BEAT GALVANOMETER.—A galvanometer whose needle comes quickly to rest instead of repeatedly swinging to and fro, through being heavily damped.

DECOMPOSITION, ELECTRIC.—The separation of a molecule into its constituent ions by means of an electric current or discharge.

DENSITY, ELECTRIC.—The amount of electricity accumulated on a unit of surface.

DEPOLARIZATION.—Checking the accumulation of gas on the collecting or generating plates of a galvanic cell.

DIELECTRIC.—That which admits the passage of electricity without conducting it; at the spark-gap of a static machine the air is the dielectric. In a Leyden jar the glass across which the electricity is propagated from the inner to the outer coating is a dielectric.

DIRECT CURRENT.—Also called continuous current (*q.v.*).

DIFFERENCE OF POTENTIAL.—When electricity moves, or tends to move, from one point to another, there is said to be a difference of potential between them.

DIFFUSION.—The power of a current to extend its influence in all directions, that power never being limited to the two electrodes.

DISCHARGE.—The passing off of the electric current when opposite polarities approximate, or a sudden equalization of potentials.

Conductive.—Discharge effected by means of a wire or other conductor, *e.g.* static wave current.

Convective.—Discharge effected by the electricity leaking off a fully-charged body quietly through the air, *e.g.* static insulation.

Disruptive.—As convective, but instead of being quiet, the discharge is accompanied by light and sound, *e.g.* spark.

Disrupto-Convective.—Midway between the two latter, *e.g.* static brush discharge.

DOUCHE, ELECTRIC.—An electrified shower-bath.

DRY CELL.—A type of cell in which the electrolyte is held in suspension by sawdust, gelatine, or some other suitable material.

DYNAMIC.—(*Dunamos*, power.) Electricity in motion, *i.e.* propagated as a current.

DYNAMO.—A magnetic electric machine which, being driven by mechanical power, causing a magnet to play in the face of coils of wire, or *vice versâ*, generates an electric current.

DYNE.—The unit of force, *i.e.* the force which, if it acted for one second on a mass of 1 gramme, would, if the mass were previously at rest, give it a velocity of 1 centimetre per second.

EARTH.—*See* Ground.

EBONITE.—Black rubber rendered hard by vulcanizing; also known as vulcanite.

ELECTRIC ANÆSTHESIA.—Insensibility to pain produced by electricity.

ELECTRIC BATH.—(*a*) Allowing an electric charge to be slowly drawn off or dissipated from an insulated patient by the surrounding air; (*b*) passing a current through water in which a patient is immersed either in whole or part.

ELECTRIC EFFICIENCY.—The ratio between the amount of current generated and the expenditure required to produce it.

ELECTRIC EFFLEUVE.—The name given to a brush discharge of a high frequency current.

ELECTRICITY.—A word derived from electron amber, being the substance in which electricity was first noticed. Electricity is a physical force manifested in several forms—magnetic, static, dynamic, and thermo-electricity—and is the name given to the unknown cause of electric phenomena.

ELECTRO-BIOLOGY.—That branch of the science of electricity which treats of the condition of living animals and the effects of electricity upon them.

ELECTRO-DIAGNOSIS.—The diagnostic use of an electric current; the galvanic and faradic are chiefly used in testing for the reaction of degeneration, for which, see books on that subject.

ELECTRODE.—(Electron, *hodos*, the way.) Some contrivance connected with a pole, a source of electric energy, which serves as a means of application of electricity to the body.

ELECTROLYSIS.—(*Lusis*, solution.) Chemical decomposition effected by means of an electric current.

ELECTROLYTE.—The fluid or semi-fluid contents of a galvanic cell other than the two elements.

ELECTROLYTIC EPILATION.—The removal of hair by electrolysis.

ELECTROPHORUS.—Instrument for obtaining electricity by induction; a terminal of an electric source.

ELECTRO-MAGNET.—A temporary magnet made by passing a current through soft iron.

ELECTRO-MASSAGE.—The application of electricity to the body during its massage (of questionable value).

ELECTROPHOBIA.—(*Phobos*, fear.) A morbid and unnecessary fear of electricity.

ELECTRO-POSITIVE.—(i) Elements which appear at the negative pole in electrolysis; the following substances, those generally used in order of E.M.F., from sodium, the most electro-positive, to carbon, the most electro-negative: sodium, magnesium, zinc, iron, lead, copper, silver, mercury, platinum, carbon; (ii) in such a state as regards electricity as to be repelled by bodies positively electrified and attracted by those negatively electrified.

ELECTROSCOPE.—(*a*) Apparatus by means of which the presence of static electricity is detected; (*b*) an apparatus for showing the presence of an electric charge or determining its polarity.

ELECTRO-THERAPEUTIC DOSAGE.—Proportioning the strength of an electric current to the duration of its application to the patient, the size of the electrode, &c.

ELECTRO-THERAPEUTICS.—(*Therapeuo*, I treat.) The application of electricity to the human body for the curing of disease or the improvement of health.

ELECTROTONUS.—A peculiar condition of a motor nerve when a continuous galvanic current is passing. *See* ANELECTROTONUS and CATELECTROTONUS.

ELEMENT.—An element is the simple and, as far as present knowledge goes, the ultimate constituent of any given matter. When we can no further split up or divide the substance, it is called an element. In electricity it is used to refer to the two elements in a galvanic cell.

E.M.F.—Electromotive force. The force of electric current which starts or tends to start electricity in motion. The maximum force of an electric current. The maximum generated difference of potential which exists in a circuit.

ENDOSMOSIS, ELECTRIC.—The unequal mixing of two liquids through the pores of an interposed septum in the passage of an electric current through the septum.

ERG.—(*Ergon*, work.) The unit of work. It is that which is effected in raising 1·981 gm. to the height of 1 centimetre.

ESSENTIAL RESISTANCE.—The resistance within the battery; internal resistance.

FARAD.—The practical unit of electric capacity.

FARADIC CURRENT.—*See* CURRENT.

FAULT.—Any defect in the proper working of a circuit due to ground contacts, cross contact, or discontinuity.

FIELD (MAGNETIC).—The space about a magnet through which its influence is active.

FIELD (STATIC).—The space round a body charged by static influence.

FILTRATION OF X-RAYS.—Passing these rays through some medium such as aluminium or boiler-felt, in order to cut off some of the softer rays and so avoid some of the superficial effects.

FLUORESCENCE.—Property by which certain substances become luminous when exposed to radiant energy, *e.g.* tunsgate of soda fluoresces when exposed to certain rays, notably the X-rays.

FLUORESCENT (FLUOROSCOPIC) SCREEN.—A screen covered with fluorescent material which permits the visual examination of the human body by means of X-rays.

FORCE, ELECTROMOTIVE.—E.M.F. (*q.v.*) electric power producing action.

FRANKLINIC ELECTRICITY, STATIC ELECTRICITY, FRICTIONAL ELECTRICITY.—Terms employed for the electricity produced by a frictional or by an electrostatic induction apparatus.

FULGURATION.—(*Fulgur*, lightning.) A method of applying well-tuned, high frequency currents by means of a special electrode for the destruction of pathological growth, also known as oscillatory desiccation and electro-coagulation.

FUSE (SAFETY).—A soft metal wire interposed in a circuit which will melt if a current too strong for safety passes through it.

FUSTIGATION.—The application of the faradic current by means of a multiple wire electrode.

GALVANIC BATTERY.—Apparatus producing galvanic electricity. The best forms of cell have a high electromotive force, an abundant quantity of current, and a constancy without loss from polarization.

GALVANIC BELT OR CHAIN.—A series of cells or links sold to be worn on the body. Possibly in some of them a mild current may be detected, of very doubtful therapeutic value.

GALVANIC CAUTERY.—*Vide supra.*

GALVANO-FARADISM.—The simultaneous application of the galvanic and faradic currents.

GALVANISM.—Voltaic, constant current electricity, that form of electricity generated by chemical action.

GALVANOMETER.—Instrument to measure and to indicate intensity direction (and other properties) of the galvanic current by deflection of the magnetic needle.

GAP-SPARK.—The space between the terminals of the two prime conductors.

GEISSLER TUBES.—Glass tubes containing residual atmospheres of gases at a low vacuum, either with or without fluorescent material, employed to obtain various luminous effects on the passage through them of high potential currents.

GENERAL ELECTRIZATION.—When the whole body is submitted to one or other forms of electricity.

GHILARDUCCI'S REACTION.—Reaction of degeneration at a distance. The electrode is not placed over the affected muscle, but the indifferent one is applied to the upper dorsal region, the active one at a point peripheral to the affected muscle; the contraction is almost exclusively a cathodal closing contraction. It persists after other reactions have failed, and its presence shows that the reaction of degeneration is complete. Otherwise,—Longitudinal reaction.

GOLD-LEAF ELECTROSCOPE.—*See* ELECTROSCOPE.

GROUND.—*See* EARTH.

GROUNDING.—Connecting a circuit to earth or ground.

HARD.—Hard and soft are terms applied to X-ray and other vacuum tubes; they refer to the relative completeness of the exhaustion therein of the retained air or residual gas. A hard tube is more completely exhausted than a low or soft tube.

HARMONIC FREQUENCIES.—A series of frequencies whose values are integral multiples of their fundamental.

HENRY (JOSEPH HENRY).—An electrical unit employed to designate a measure of induction, when the inducing current varies one ampere per one second and the electromotive force in the circuit is one volt.

HERTZIAN WAVES.—Electro-magnetic waves given off from either an electro-magnet whose intensity is undergoing rapid variations, or from a circuit whose strength is being rapidly varied, or through which an oscillatory discharge is passing.

HOT-WIRE METER.—A meter whose readings are based on the expansion of a wire, due to an increase of temperature, by the passage through it of the current that is to be measured.

HYDRO-ELECTRIC BATH, in which electricity is conveyed to the patient through the medium of water.

HYDRO-ELECTRIZATION.—Employment of water as an electrode as in the hydro-electric bath.

HYSTERESIS.—A term applied to residual effects in the rapid magnetization and demagnetization of a soft iron core lying within a coil of insulated wire, through which an interrupted constant current is flowing.

INCANDESCENCE.—(*Incandesco,* I glow.) The glowing condition of a substance in a white heat.

INCREASED ELECTRIC IRRITABILITY.—Irritability of nervous or muscular tissue produced by a much weaker electric current than that required to produce it in normal tissue.

INDUCED CURRENT.—That secondary current produced by induction. It flows in the opposite direction to the primary or inducing current when the latter is made, but in the same direction when it is broken.

INDUCTION.—(*Induco,* I lead in.) The production of a charge, a current, or electrical properties in a body brought near another already possessing these properties.

INDUCTION COIL.—An apparatus consisting of two associated coils of insulated wire employed for the production of currents by mutual induction.

INFLUENCE.—A word used in place of induction.

INITIAL CHARGE.—A charge excited on glass or rubber, and conveyed to the plates of a static machine by contact.

INSULATION.—(*Insula,* an island.) The prevention of a free escape of electricity by supporting or surrounding the electric machine with a non-conductor or bad conductor, *e.g.* glass, rubber, shellac.

INSULATOR.—A non-conductor or a bad conductor, *e.g.* glass, rubber, shellac.

INTENSIFYING SCREENS.—Sheets of celluloid coated with some fluorescing material, such as tungstate of calcium, placed in contact with the film side of the X-ray plate; the time necessary for exposure is materially shortened.

INTERRUPTED CURRENT.—A current from a circuit which is alternately opened and closed.

INVERSE CURRENT.—(i) The current which tends to be produced by a current in its own circuit on making or closing the circuit; (ii) the current produced in the secondary of an induction coil on the making or completion of the circuit of the primary. Inverse currents flow in the opposite direction to the original current.

IONS.—(*Ion*, going, traveller.) The groups of atoms into which a molecule is separated by electrolytic decomposition, and which appear at the positive or negative pole—cations at the negative; anions at the positive.

JAR, LEYDEN.—A jar, usually of glass, more or less coated within and without with tin-foil, having in the centre and passing through the cover a metal rod, the whole forming a condenser.

JOLLY'S REACTION.—Seen in certain atrophic muscular conditions, the muscles being voluntarily excitable after withdrawal of the faradic current.

JOULE.—The amount of energy employed in maintaining a current of one ampere for one second against a resistance of one ohm—10,000,000 ergs.

KAOLIN.—A special kind of clay used for making certain electrodes, chiefly indifferent dispersive pads.

KATHODE.—The negative terminal in a battery or other source of electric energy.

KATION, KATHODE.—*See* CATION, CATHODE.

KILOWATT.—1000 watts.

LABILE.—(*Labilis*, apt to slip.) Term used to designate that mode of application of electricity in which the active electrode is passed to and fro over the part under treatment.

LAMP, ARC.—An electric lamp where the light is produced by the electric arc passing between two terminals, usually carbon.

LAMP, INCANDESCENT.—An electric lamp where the light is produced by the electric current bringing a filament to a white heat; the filament is enclosed in a bulb, which has been brought to a partial vacuum.

LEAKAGE, ELECTRIC.—The dissipation of a charge or current due to insufficient insulation.

LEYDEN JAR.—*See* JAR.

LIGHT BATH.—*See* CHAPTER X.

LINE OF FORCE.—The direction in which a charged body placed at a given point tends to move.

LINES OF MAGNETIC FORCE.—The curve lines through which the force emanating from a magnet acts (these may be illustrated by holding the poles of a magnet against a sheet of stiff paper upon which iron filings are sprinkled).

LIVE WIRE.—A wire connecting with an electric source through which a current is passing, or will pass if touched and so connected to earth.

MAGNET, ELECTRO-.—*Vide supra.*

MICRO-FARAD.—Practical unit of capacity.

MILLIAMPERE.—$\frac{1}{1000}$ of an ampere.

MILLIAMPERE METER.—An instrument made to record the strength of a current passing in fractions of an ampere.

MILLIAMPERE MINUTE.—The milliamperage used in a given treatment multiplied by the number of minutes during which that milliamperage was flowing.

MOTOR.—A machine which converts electricity into mechanical energy.

MOTOR POINTS.—The point of entrance of a motor nerve into a muscle; over such a point the application of a suitable current will produce contraction of a muscle in health. Of chief importance in testing for Reaction of Degeneration.

The points on the surface of the body where the various branches of the motor nerve supplying the muscles may be best affected by electricity.

NEGATIVE ELECTRICITY.—Originally referred to that form of electricity produced on sealing-wax or resin when rubbed with cotton.

NEGATIVE ELEMENT.—The zinc or other element from which negative electricity is obtained, though it should be remembered that the portion of this same element which is immersed in the fluid is electro-positive.

NON-CONDUCTOR.—A substance which does not freely transmit electricity, *e.g.* glass, paraffin, rubber ; an insulator.

OHM.—Practical unit of electrical resistance. It was decided (Paris Congress 1884) that the legal ohm is the resistance offered by a column of mercury 106 cm. high 1 square mm. in cross section, having about the resistance of 100 metres of telegraph wire.

OHM'S LAW.—The strength of the current varies directly as the E.M.F. and inversely as the resistance of the circuit, or the current expressed in amperes is equal to the E.M.F. expressed in volts divided by the resistance expressed in ohms.

$$C = \frac{E}{R}.$$

The law was enunciated by Dr. G. S. Ohm, and is used for showing the relation between Electromotive Force, Resistance and Current.

OPEN CIRCUIT.—A circuit whose conducting continuity is broken.

OPENING CONTRACTION.—*See* CONTRACTIONS.

OSCILLATION, ELECTRIC.—(*Oscillo*, I swing.) The to-and-fro movement in a current.

OSCILLOSCOPE.—A vacuum tube, constructed so as to show whether a current is unidirectional or oscillatory, and in the latter case roughly in which direction the greater quantity of current is flowing.

PARALLEL.—Cells are said to be parallel when the positive elements are all connected to each other, and the negative are similarly connected. The E.M.F. is only equal to the E.M.F. of one cell, but its internal resistance is diminished in proportion to the number of cells thus joined. *See* SERIES.

POLARIZATION.—When the hydrogen set free in a cell is permitted to collect around the carbon, and so interfere with the chemical action which generates the electricity, the cell is said to be polarized.

POLE CHANGER.—A device for changing the direction of the current.

POLE TESTER.—Any device for readily determining the polarity of the current, *e.g.* wet blue litmus paper will turn red in contact with the positive pole from a galvanic battery; the red spot will become blue again on the application of the negative pole; or when the end tips are placed in water and a galvanic current is turned on, bubbles of hydrogen will rise from the negative side, while the positive tip will become blackened.

POSITIVE ELECTRICITY originally referred to that form of electricity produced on cotton when rubbed with sealing-wax or resin.

POSITIVE ELEMENT.—The carbon or other element from which positive electricity is obtained, though it should be remembered that the portion of this same element which is immersed in the fluid is electro-negative.

POTENTIAL.—(*Potentia*, power, ready to act, but not yet acting.) It is the condition of electrical tension of a body. This term holds the same relation to electricity that the term level does to gravity; just as water at a higher level tends to move to a point of lower level, so does the accumulation of electric energy, at that point in the circuit at which it is present in excess over any other point in the circuit, tend to seek that point in the circuit at which it is lowest, so that electrical equilibrium may be restored.

PHOTO-THERAPY.—The remedial action of light in the treatment of disease; the light may be that emitted from an arc light, the incandescent light, X-ray or any other form of light.

PRIMARY CELL.—A galvanic cell.

PRIMARY CURRENT.—The inducing current from the primary coil.

RAY.—A line of light, heat, or other form of radiant energy.

RAY, ACTINIC.—*See* ACTINIC RAY.

RAY, BECQUEREL.—Rays emitted by radio-active substances, such as radium; first discovered by Becquerel in uranium.

RAY, CATHODE.—*Vide supra.*

RAY, RÖNTGEN OR X.—Rays emitted from the source of radiant energy excited by a discharge of electricity within a vacuum tube, not deviable by a magnet or refracting medium; they pass through opaque bodies, cause certain substances to fluoresce, affect a photographic plate like light rays, and they have peculiar therapeutic and pathological effects upon living tissue.

RAY, ULTRA-VIOLET.—Invisible rays whose luminous frequencies are greater than that of the violet rays of the spectrum.

REACTION.—Muscular contractions following the closing or opening of an electric current.

REACTION OF DEGENERATION.—Alteration or decrease of the normal reaction of muscles and nerves to faradic and galvanic stimulation.

RECTIFIER.—An apparatus which is used to transform an alternating current into what is practically a unidirectional current. There are several kinds of rectifiers, the simplest of which is the "aluminium cell."

RESIDUAL CHARGE.—A feeble charge of electricity which can be obtained from a condenser after it has been discharged.

RESISTANCE (*a*).—That which opposes the current flow.
„ (*b*).—The ratio of E.M.F. to the current strength;

$$C = \frac{E}{R}.$$

RESISTANCE COIL.—Wire coil used for calculating or reducing the current.

RESISTANCE, INTERNAL, ESSENTIAL.—Resistance having its origin within the cell or generating apparatus.

RESONATOR.—A circuit tuned to oscillate in synchronism with another oscillating in alternating circuit.

RHEOMETER.—Galvanometer.

RHEOPHORE.—(*Phoreo,* I bear.) Cord or wire conducting electricity.

RHEOSCOPE.—Instrument for determining the presence of electricity.

RHEOSTAT.—(*Rheos,* current, *histemi,* I stand.) An instrument for regulating the resistance to an electric current.

RHEOTOME.—(*Temno,* I cut.) Instrument used to interrupt an electric current.

ROTARY CONVERTER.—A secondary generator for transforming alternating into continuous currents or *vice versâ,* consisting of an alternating-current machine whose armature winding is connected with a commutator; or of a continuous-current machine whose armature is tapped at symmetrical points and connected to collector rings, so that, when the armature runs, it is an alternator on one side and a direct current machine on the other.

RUHMKORFF COIL.—A powerful induction coil invented by Ruhmkorff.

SABOURAUD'S PASTILLES.—Pastilles of light green colour, called by Sabouraud tint A, which turned to an orange colour, called by Sabouraud tint B, on being exposed to X-rays, thus measuring the dose.

SECONDARY BATTERY.—(*Secundus,* second.) Storage battery.

SELF-INDUCTION.—Induction produced in a circuit by the induction of a current on itself at the make or break of the current therein.

SECONDARY COIL.—A coil of wire in which the induced or secondary current is generated.

SERIES.—Cells are said to be in series when the positive element of one cell is connected with the negative element of the next cell, and so on. The electromotive force of the combination, measured from the positive pole of the first to the negative pole of the last, is thus increased, *e.g.* in a battery with three cells, each having an E.M.F. of 1·5, the total E.M.F. will be volt 4·5.

SHOCK.—(*a*) A sudden discharge of electricity from a Leyden jar or a body charged with static electricity. (*b*) The effect made on a body by opening or closing a circuit suddenly.

SHORT CIRCUIT.—(*a*) A circuit of limited extent formed between two points on a larger circuit. (*b*) A current limited to battery cell.

SOLENOID.—A cylindrical coil of wire whose convolutions are circular.

SINUSOIDAL.—A sinusoidal current is an alternating current whose alternations occur gradually; the potential in one direction is gradually overcome, neutralized, and finally succeeded by an equal amount of potential in the opposite direction. Diagrammatically these changes follow the line of a sine curve ; hence the name.

STABILE CURRENT.—*Vide supra.*

STATIC ELECTRICITY.—(*a*) A term applied to electricity produced by friction. (*b*) Electricity at rest in equilibrium, as opposed to current electricity.

STATIC MACHINE.—A machine for generating static electricity.

SUPPLY, UNIT OF.—Board of Trade unit.

SWITCH.—A metallic bar revolving on a pivot used to open and close a current, and as cell selectors, pole changers.

TAPE, INSULATING.—Tape impregnated with insulating material.

TENSION, ELECTRIC.—A term used variously to describe E.M.F., dielectric stress, or difference in potential.

THERMO-ELECTRIC.—Relating to electricity produced by heat ; generating electricity by heat, or *vice versâ.*

THERMO-ELECTRIC CAUTERY.—*See* CAUTERY.

THERMO-ELECTRIC PILE.—A collection of bars of metal soldered together: when heated, an electric current is developed which moves an index that accurately registers the amount of heat.

TRANSFORMER.—*See* CURRENT TRANSFORMER.
" A STEP UP.—Is one which raises the pressure.
" A STEP DOWN.—Is one which lowers it.

UNIPOLAR.—Possessing a single pole ; or where one pole is the active electrode and the other merely dispersive.

UNIT MEGOHM.—1,000,000 ohms.

UNIT MICRO-FARAD.—$\frac{1}{1,000,000}$ farad.

UNIT MICRO-VOLT.—$\frac{1}{1,000,000}$ volt.

UNIT MILLIAMPERE.—$\frac{1}{1000}$ ampere.

UNIT OF CURRENT.—That current which is given by an E.M.F. of 1 volt acting through a resistance of 1 ohm; that is, $\frac{1}{10}$ of the absolute unit = 1 ampere.

UNIT OF E.M.F.—Consists of 100,000,000 absolute unit = 1 volt, and is a little less than the E.M.F. of one Daniell's cell.

UNIT OF QUANTITY.—One ampere for one second carries one coulomb of electricity that passes in a second in a conductor which has resistance of 1 ohm with E.M.F. of one volt.

UNIT OF RESISTANCE.—1,000,000 absolute units. *See* OHM.

VACUUM.—A space from which nearly all traces of gas have been removed.

VACUUM TUBE.—Glass tubes or bulbs from which nearly all traces of gas have been removed.

VOLT.—The practical unit of E.M.F. An E.M.F. which would cause a current of one ampere to flow against a resistance of one ohm.

VOLTMETER.—An instrument for measuring difference of potential.

VULCANITE.—*See* EBONITE.

WATT.—Is a volt-ampere, or unit of electrical force.

X-RAYS.—The invisible rays emitted by an electrically excited Crooks' tube, which are capable of penetrating many substances opaque to light and of producing actinic or fluorescent effects.

ZERO, POTENTIAL.—The earth's potential.

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